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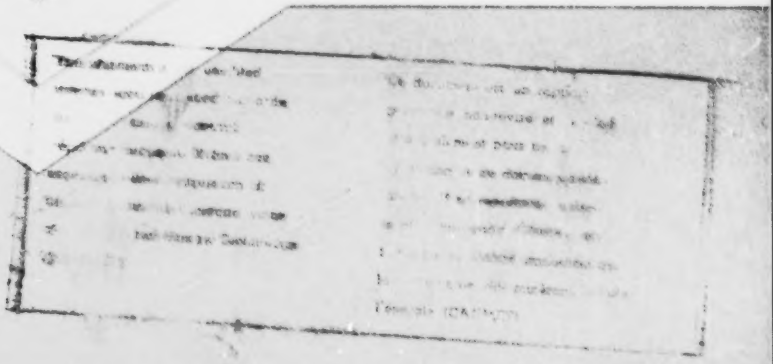
CANMET

Canada Centre for Mineral and Energy Technology
Centre canadien de la technologie des minéraux et de l'énergie



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Mineral & Energy Technology Mining Research Laboratories Division Report M&ET/MRL 86-53(TR)

Compiled and Edited by
D.M. Hill

86-06673/

FOREWORD

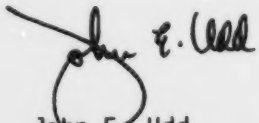
This Annual Report of the Mining Research Laboratories of CANMET contains an overview of the accomplishments of the Division's staff during the 1985-1986 fiscal year. As a complete and brief summary of the efforts during the period, it is a valuable document. Distribution of it is made to key personnel within CANMET and the private sector.

The report has been prepared through the contributions of many MRL staff members. Project leaders have prepared brief summaries of the progress made on the research for which they were responsible. The administrative staff, principally Donna Hill, have provided tabulations of: publications; research contracts; participation in technical committees; and staff.

The 1985-1986 fiscal year was one of intense activity in the Division. Several new research projects were initiated under the Mineral Development Agreements (MDAs) between the federal government and the provinces of Manitoba, Ontario, and New Brunswick. MDA-related research has increased at such a rate during a very short period that it now dominates the externally sponsored work of the Division. Two of the most important benefits to MRL have been the initiation of large-scale projects in operating mines and a growth in research activity. Both will be of lasting value.

Additionally, during the year, the work on a co-operative tripartite rockburst research project (involving MRL, the government of Ontario, and the Ontario Mining Industry) was begun. Late in 1985, the Division also took occupancy of the new laboratory which had been constructed in the town of Elliot Lake. The new facilities represent a vast improvement, although, understandably, the move resulted in some delays in project work. Fortunately, most of the work is now proceeding according to schedules.

Because of the initiation of new projects and the move into new facilities at Elliot Lake, the staff of the Division has worked at a rapid and sustained pace throughout the year. Given present resources it is becoming more and more difficult to respond to the numerous requests that are made, either for technical assistance or for the evaluation of reports and proposals. In spite of difficulties with resources, the staff has responded promptly to all such requests during the past year. It is noteworthy that many of these have been from smaller mining operations, particularly in Quebec.



John E. Udd
Director
Mining Research Laboratories

AVANT-PROPOS

Ce Rapport annuel des Laboratoires de recherche minière du CANMET présente un aperçu des réalisations du personnel de la Division au cours de l'année financière 1985-1986. En tant qu'exposé bref et complet des efforts déployés durant cette période, il est un document précieux. Le rapport est distribué au personnel clé au sein du CANMET et au secteur privé.

Le rapport a été préparé grâce à la collaboration de plusieurs membres du personnel du LRM. Les chefs de projets ont collaboré en préparant de brefs résumés des progrès accomplis dans les projets de recherche dont ils étaient chargés. Le personnel de l'Administration, particulièrement Donna Hill, a préparé une liste des publications, des contrats de recherche, des participants aux comités techniques et du personnel.

L'année financière 1985-1986 a été une année d'activités intenses au sein de la Division. Plusieurs nouveaux projets de recherche ont été créés dans le cadre des Ententes sur le dévelloppement minèral (EDM) entre le gouvernement fédéral et les provinces du Manitoba, de l'Ontario et du Nouveau-Brunswick. Les travaux de recherche rattachés aux EDM ont augmenté à un tel rythme en si peu de temps qu'ils dominent actuellement les travaux de recherche externes parrainés par la Division. Deux points des plus profitables aux LRM ont été la création de projets de recherche minière de grande envergure et l'augmentation des activités de recherche. Ils demeureront tous deux d'un intérêt permanent.

De plus, au cours de l'année, on a commencé des travaux sur un projet de recherche coopératif tripartite sur les coups de toit (les parties étant le LRM, le gouvenement de l'Ontario et l'industrie minière de l'Ontario). Vers la fin de 1985, la Division a pris pocession d'un nouveau laboratoire construit dans la ville d'Elliot Lake. Les nouvelles installations repésentent une grande amélioration bien que, naturellement, le déménagement ait occasionné quelques retards dans les travaux de recherche. Heureusement, la plupart des travaux avancent maintenant comme prévu.

En raison de la création de nouveaux projets et du déménagement dans de nouvelles installations à Elliot Lake, le personnel de la Division a travaillé a un rythme rapide et soutenu durant toute l'année. Étant donné les ressources actuelles, il devient de plus en plus difficile de répondre aux nombreuses demandes qui nous sont adressées soit pour obtenir du soutien technique, soit pour effectuer l'évaluation de rapports et de propositions. Cependant, malgré les difficultés occasionnées par le manque de resources, le personnel a répondu rapidement à tous ces genres de demandes au cours de la dernière année. Il convient de noter que plusieurs de ces demandes provenaient de petites exploitations minières, tout particulièrement du Québec.

John E. Udd
Directeur
Laboratoires de recherche minière

INTRODUCTION

The Mining Research Laboratories are comprised of four units:

CANADIAN EXPLOSIVES ATMOSPHERES LABORATORY (CEAL):

This is a national test laboratory for the certification of underground mining equipment and materials on behalf of provincial mines inspectors. The test program is complemented by research on emissions from diesel equipment. Miners' health and safety is the main concern, particularly in coal mines, where the atmosphere can be explosive.

ROCK MECHANICS LABORATORY (RML):

Mineability and operational technology: Mathematical models are being developed for the structural analysis of surface and underground mines. Specific mine structures are analysed as part of comprehensive ground control studies. Methods are also being developed to determine the mechanical properties of rock and support systems essential to mathematical modelling of structures.

Reserve evaluations: Mineability and ore reserve evaluation studies are presently being carried out on uranium and coal. Included in this activity is the development of new methodologies for mineral reserve evaluation. In support of the studies, mine operation technology, productivity factors and production projections are also being researched.

CANADIAN EXPLOSIVES RESEARCH LABORATORY (CERL)

The full range of commercial explosives and pyrotechnics are examined for safety and integrity, and advice is given on their suitability under the Canada Explosives Act. The work extends to the measurement of poisonous gases produced by explosives, dust explosion hazards and spontaneous combustion of coal.

ELLIOT LAKE LABORATORY (ELL):

Working closely with the mining industry, research is conducted in the laboratory and at mine sights in three areas - Rock Mechanics, Underground Environment and Surface Environmental Controls.

In Rock Mechanics, the majority of the group's activity is related to underground stability, including rockbursts. The effects of geological structures, gravitational forces and mine layout on rockbursts are under study. Computer modelling, with input from underground instrumentation, should lead to alternative mine designs and layouts aimed at alleviating failure of underground workings.

Underground Environmental studies in dust radiation, ventilation and noise measurement and control are supported by instrumentation development in the laboratory. Computer modelling of ventilation systems will assist in understanding how improvements can be instituted. A dust/ventilation tunnel, being installed soon, will provide a simulated mine passage for laboratory experimentation.

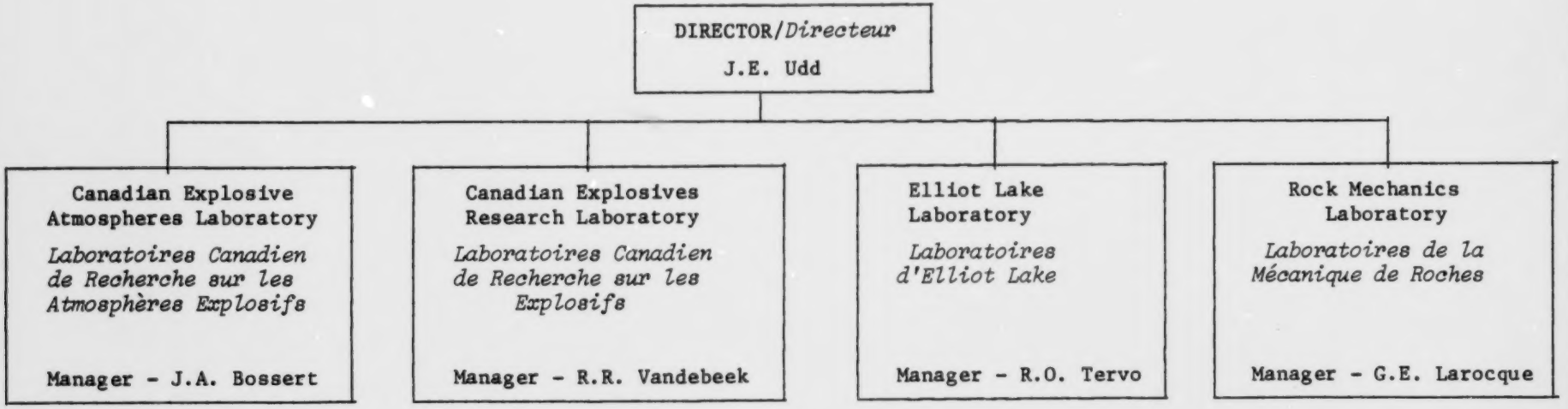
The national radiation instrumentation calibration facility will provide calibration service to mining companies and governmental agencies while also providing a simulated mine atmosphere for developing and testing new instrumentation.

Surface environmental studies are being conducted at mine sites under CANMET's reactive acid tailings research program to obtain a fuller understanding of the pathways by which contaminants may travel from tailings piles into the surrounding environment. Here again, field studies are supported by laboratory experimentation and computer modelling, aimed at developing control techniques and future abondonment policies.

Projects are funded through the Minerals and Energy Technology, and the Administration of the Canada Explosives Act Activities. Most of the work of CERL is funded through explosives-related activities and the majority of CEAL work is funded through the Energy Technology activity. The work of the Elliot Lake and Rock Mechanics Laboratories is funded through the Minerals and Energy Technology activities.

MINING RESEARCH LABORATORIES

LABORATOIRES DE RECHERCHE MINIÈRE


DIRECTOR/*Directeur*
J.E. Udd
Canadian Explosive Atmospheres Laboratory
Laboratoires Canadien de Recherche sur les Atmosphères Explosifs
Manager - J.A. Bossert
Canadian Explosives Research Laboratory
Laboratoires Canadien de Recherche sur les Explosifs
Manager - R.R. Vandebeek
Elliot Lake Laboratory
Laboratoires d'Elliot Lake
Manager - R.O. Tervo
Rock Mechanics Laboratory
Laboratoires de la Mécanique de Roches
Manager - G.E. Larocque

INTRODUCTION

Les Laboratoires de recherche minière comprennent quatre installations dont:

LE LABORATOIRE CANADIEN DE RECHERCHE SUR LES ATMOSPHERES EXPLOSIVES (LCRAE):

Le LCRAE est un laboratoire national d'étalonnage qui mène des essais en vue d'homologuer l'équipement et le matériel utilisés dans la mine souterraine pour le compte des inspecteurs provinciaux des mines. Des activités de recherche ayant trait au gaz d'échappement des moteurs diésels complémentent le programme d'étalonnage. La préoccupation principale sous-jacent les activités du laboratoire est la santé et la sécurité des mineurs, en particulier de ceux qui oeuvrent dans les mines de charbon souterraines où l'atmosphère peut être explosive.

LE LABORATOIRE DE RECHERCHE SUR LA MECANIQUE DES ROCHES (LRMR):

Techniques et possibilités d'exploitation: Des modèles mathématiques sont actuellement mis au point pour l'analyse structurale des mines souterraines et des mines à ciel ouvert. Des structures minières déterminées sont analysées dans le cadre d'études d'ensemble portant sur le contrôle des mouvements du terrain. Des méthodes sont également développées en vue de déterminer les propriétés mécaniques des roches et les systèmes de soutènement qui sont essentiels à la modélisation mathématique des structures.

Evaluation des réserves: Des études portant sur l'évaluation des réserves de minerai et les possibilités d'exploitation de l'uranium et du charbon sont actuellement en cours. Cette activité comprend également la mise au point de nouvelles méthodes d'évaluation des réserves minérales. Dans le cadre de ces études, les techniques d'exploitation minière, les facteurs de productivité et les prévisions relatives à la production font également l'objet de recherches.

LABORATOIRE CANADIEN DE RECHERCHE SUR LES EXPLOSIFS (LCRE):

4 La gamme entière d'explosifs et de produits pyrotechniques commerciaux est étudiée de façon à ce que l'on puisse établir l'intégrité et la sécurité des produits et déterminer s'ils sont conformes aux critères et propres à être utilisés en vertu de la Loi canadienne sur les explosifs. Les travaux comprennent la mesure des émissions de gaz toxiques que dégagent les explosifs, les risques inhérents aux explosions de poussière et à la combustion spontannée du charbon.

LABORATOIRE DE RECHERCHE D'ELLIOT LAKE (LREL):

En collaboration étroite avec l'industrie minière, le LREL mène des recherches en laboratoire et sur les chantiers d'exploitation dans trois domaines - le contrôle de la mécanique des roches, de l'environnement souterrain et de l'environnement en surface.

La plupart des activités du groupe qui oeuvre dans le domaine de la mécanique des roches ont trait à la stabilité souterraine, y compris les coups de toit. Les effets des structures géologiques, des forces de gravité et de la disposition du chantier font l'objet d'une étude. La modélisation de systèmes assistée de l'ordinateur, secondée par l'appareillage de ventilation en milieu souterrain, devrait susciter une nouvelle approche quant à la conception et l'aménagement des chantiers de façon à atténuer les risques de détérioration qui menacent les ouvrages souterrains.

Les études environnementales portant sur le contrôle et la mesure des rayonnements émis par la poussière, de la ventilation et du bruit en milieu souterrain sont secondées par la mise au point d'appareils de contrôle en laboratoire. La modélisation informatisée des systèmes de ventilation permettra de déterminer la façon de procéder pour apporter les améliorations requises. Un tunnel poussière/ventilation qui sera bientôt percé constituera un passage de mine simulé pour les expériences en laboratoire.

L'installation nationale pour l'étalonnage de l'appareillage servant à la mesure des rayonnements fournira un service d'étalonnage aux sociétés minières et aux organismes gouvernementaux tout en offrant également une atmosphère de mine simulée pour la mise au point et l'essai du nouvel appareillage.

Dans le cadre du projet de recherche du CANMET sur les résidus contenant des acides réactifs, des études environnementales en surface sont effectuées sur le chantier d'exploitation dans le but de favoriser une meilleure compréhension des voies qu'empruntent les polluants dans leur trajet à partir des amas de résidus jusque dans l'environnement avoisinant. Une fois de plus, les études sur le terrain sont secondées par les expériences et la modélisation informatisée en laboratoire, activités qui visent à mettre au point des techniques de contrôle et des lignes directrices concernant l'abandon des résidus.

Les projets sont financés dans le cadre des activités de recherche sur la technologie minérale et énergétique et en vertu de l'Administration de la Loi canadienne sur les explosifs. La plupart des activités de LCRE sont financées par le biais des activités de recherche sur les explosifs, et la majorité des travaux du LCRAE sont financés par l'intermédiaire de travaux de recherche sur la technologie énergétique. D'autre part, les travaux effectués au Laboratoire d'Elliot Lake ont été financés dans le cadre des activités de recherche sur la technologie minérale et énergétique.

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PART I

ADMINISTRATION OF THE CANADA EXPLOSIVES ACT

CANADIAN EXPLOSIVES RESEARCH LABORATORY

HIGHLIGHTS

During 1985/86, the Canadian Explosives Research Laboratory examined 351 explosives for authorization under the Canada Explosives Act. The laboratory continued to provide technical advice on explosives, including an evaluation of the response of a bomb technician's protection suit to incendiary type devices. A draft standard for fireworks was also completed, the first time such a standard has been prepared in Canada.

The laboratory continued its investigation into the thermal properties of explosives, in particular, studying the properties of tetryl and ammonium nitrate. Several instrumental improvements were implemented for measuring explosive properties. The evaluation of the test procedures under the U.N. Classification System has been completed and these procedures implemented for routine testing of explosives. The contract on the verification of the high velocity impact model is about complete. It is believed that this is the first time that the techniques used in this contract have been applied to commercial explosive systems and that the methodology sheds light on the question of impact sensitivity and permits quantification of the phenomenon for use in hazard studies.

SUB-SUB ACTIVITY: EXPLOSIVES TECHNOLOGY

CERTIFICATION AND TECHNICAL ADVICE

Project Leader: E. Contestabile

Objectives

1. To confirm the safety characteristics of all submitted explosives for authorization under the Canada Explosives Act;

2. to provide technical advice on the manufacture, storage and transportation of explosives; and

3. to investigate accidents.

Background

The Certification and Technical Advice project of the Explosives Technology sub-activity has been developed to fulfill the requirement for a "chemist" specified in Section 14 of the Canada Explosives Act. During the 65 years in which the Act has been in force, the laboratory functions of certificating explosives, advising on technical problems of explosives, advising on technical problems of explosives handling and investigating accidents involving explosives have continuously been developed. The expertise in Explosives Safety Engineering is developed in-house through contact with manufacturers' laboratories, contracted research projects, in-house development projects and international contacts. Because of the proprietary nature of commercial formulations, results of individual examinations for authorization are, and remain, confidential.

Responsibilities under the project continue to increase because of technical advances in formulation, added international responsibilities as a major explosives producing country and increasingly critical reactions from the Canadian public to accidental explosions.

Achievements

During the year, 351 new explosives were examined for authorization. These involved some 2528 sample units of work. Corresponding figures for year 1984/85 were 347 and 2544, respectively, and for 1983/84 were 184 and 2013. Details of the samples by Classes are to be found in the "Summary of Samples Examined" section of this report.

After a significant decline in the number of samples submitted to the laboratory during the period 1981 to 1983, the number has returned to a level that is considered more usual based upon past experience. The breakdown of samples by Explosives Class is similar to that for samples received in 1984.

Certification and Technical Advice

- E. Contestabile operating the Ballistic Pendulum to establish explosive strength

There were no major accidents in explosives manufacturing during the past year which required the laboratory's involvement. The study into the cause of an explosion of a pipe carrying ammonium nitrate (AN) was continued. The laboratory investigation into this explosion had previously been reported [ACEA/MRL 85-16(TR)], however, several areas which had been identified for further work were pursued. These areas included large scale studies of the thermal stability of AN at elevated temperatures (in progress), reactivity of metals with AN [ACEA/MRL 86-29(TR)], decomposition of AN below its melting point [ACEA/MRL 86-21(TR)] and an analytical study of the products formed by the reaction of AN with various metals (in progress).

A specialized shipping container based upon a commercially available letter vault was designed and evaluated for Babcock and Wilcox to permit shipment by air of tube expansion charges for heat exchangers. A series of fireworks trials conducted by the U.S. Bureau of Mines at Cadiz, Ohio were observed. Additional tests by CERL are planned for 1986/87. A bomb technician's protection suit was evaluated for the RCMP to evaluate its response to attack by incendiary type devices [ACEA/MRL 86-37(CF)]. Assistance is being given to Korlin Concentrates to determine the cause of an aluminum dust explosion that killed one man and injured a second.

The laboratory has completed a draft standard for Class 7.2 Fireworks. This is the first time that such a standard has been drafted in Canada. The analytical chemistry manual used by CERL has been reviewed and updated to reflect new and improved methodologies. A manual has also been developed for reporting test results using the laboratory's computerized database.

EXPLOSIVES RESEARCH AND DEVELOPMENT

Project Leader: K.K. Feng

Objectives

To advance technology related to the manufacture, storage, transportation and use of explosives, specifically:

- by 1985 to characterize the safety properties of the new emulsion explosives;
- by 1986 to verify the proposed United Nations classification procedures for incorporation into the Canada Explosives Act and Regulations;
- by 1988 to develop a theoretical model for predicting low velocity impact sensitivity of bubble-sensitized slurry explosives; and
- by 1989 to develop a risk analysis methodology applicable to explosives.

Background

Canada is working with other countries under the auspices of the United Nations to develop a unified, international classification system for dangerous goods, including explosives. Current planning is for the Canada Explosives Act to be amended to adopt the proposed new standards by 1987. CANMET is evaluating the proposed new standards which are based on a hazard assessment system, together with test procedures used in other countries

against the current Canadian standards, which are based on a chemical classification system, and CANMET test procedures to ensure that no significant changes in explosive classification would result. CANMET is acting in a lead agency role together with parallel agencies in other countries in this international evaluation of the proposed new standards. This work is planned for completion in 1986.

As part of an ongoing effort, the laboratory is continuing to upgrade explosives test and evaluation procedures. A new fume testing facility is under construction, a large scale impact test is being assessed and improved electronic units for detonation velocity measurements and other testing are in progress.

Due to the cost and complexity of testing bulk samples of explosives for safety characteristics, CANMET has concentrated for several years on the development of computerized modelling capability to evaluate such parameters as detonation sensitivity, fume generation and propagation properties, based on chemical constituents of explosives. This modelling work has reached the stage where field verification using large samples is necessary. This work is currently being done under contract.

Achievements

During 1985/86, CERL continued to study the thermal stability of explosives using its accelerating rate calorimeter (ARC). To obtain a better understanding of the ARC's ability to determine decomposition mechanisms of explosives and provide reasonable kinetic data, a detailed study of tetryl was undertaken. It was found that activation energies calculated from ARC data were somewhat higher than those determined using isothermal methods but lower than those determined using such classical techniques as DSC and DTA. The ARC technique identified the two major decomposition peaks for tetryl and, as a result of the ARC using a fairly large sample, the intermediate products were analyzed and found to be primarily trinitroanisole and picric acid. The second decomposition peak describes the decomposition of the picric acid. The results are detailed in two reports [ACEA/MRL 86-23 and 86-24(J)] which have been accepted by Thermochimica Acta for publication.

The installation of a new fume testing facility is proceeding with only the electrical work remaining. This should be completed by the end of June. A novel system of explosives containment has been developed and evaluated that permits the explosive to do work yet does not destroy the system on every shot [ACEA/MRL 85-102(TR)]. Several new electronic systems have also been developed to measure the velocity of projectiles [ACEA/MRL 85-68(TR)] and to measure the velocity of detonation of explosives [ACEA/MRL 85-104(TR)]. A report on the laboratory's modified impact tool was also issued [ACEA/MRL 85-84(TR)]. A new large scale drop weight test (impact tool) was designed and a preliminary evaluation completed [ACEA/MRL 85-119(TR)]. A user's guide was prepared for a multi-channel high speed digital storage system [ACEA/MRL 85-121(INT)].

The laboratory continued its modification to a thermohydrodynamic model (Tiger Code) to predict explosive properties including detonation fumes. Two reports were issued [ACEA/MRL 85-100(TR) and 85-143(TR)]. A total of eight different explosive compositions were evaluated for the Explosives Branch using this Code.

One report on the use of shaped charges in mining operations was published in the CIM Bulletin (December, 1985, pp 41-46). A second paper on the calculation of detonation products by means of an equation of state was presented to and published in the Proceedings of the 8th International Symposium on Detonation.

In addition to in-house research, the laboratory also supports research under contract. Currently, three contracts are in place. The first contract is on the experimental verification of a high velocity impact model that had been developed both in-house and under contract. It has a termination date of May 30, 1986. As the explosives industry moves increasingly to bulk or large diameter explosives, the ability to quantify the hazards of these explosives is more and more difficult and costly. To address this concern, a theoretical model predicting the response of explosives to stimuli such as impact was developed. Consequently, to determine the validity of this model, an experimental study was required and this contract was awarded. The project has been well worthwhile, and with the exception of those explosive compositions which contain large TNT prills, the Pop plots have been quite consistent and the reactive hydrodynamic model has produced prediction in good agreement with experimental projectile or explosively driven flyer plate results, and projectile diameter effects. The predictive system in use consists of a reactive hydrodynamic code which employs Arrhenius burning laws or the Forest Fire burning law in conjunction with the HOM equation of state. It is believed that this is the first time that such techniques have been applied to commercial explosive systems and that the methodology sheds light on the question of impact sensitivity and permits quantification of the phenomenon for use in hazard studies.

A second contract on the propagation sensitivity of commercial explosives in 15 cm diameter boreholes was awarded in December 1985 for completion in August 1986. This contract is a follow-up to work done in 25 - 50 mm diameter boreholes to address problems encountered in decked blasting.

The second year of a three-year contract on the development of a theoretical model for predicting the low velocity impact sensitivity of bubble-sensitized slurry explosives has been completed. During the year, the shock to detonation model was tested and evaluated for the prediction of impact initiation of explosives. It reproduced experimental results for Composition B and Magnafrac 100 when these explosives are impacted by aluminum flyer plates. The projectile impact test showed that even with small diameter, cap-sensitive slurry explosives that impact velocities of approximately 200 m/sec or greater are required to produce detonation.

Work continued on verification of U.N. classification procedures. The laboratory has the capability and the necessary experience to perform at least one test in each of the first five Test Series. The laboratory does not have the quantity/distance requirements to do Test Series 6. However, as the laboratory has access to manufacturer's facilities or military installations, this is not regarded as a problem. No difficulties have been encountered in using the U.N. procedures to classify explosives for transportation purposes.

Explosives Research and Development

- Large open pit blast at Iron Ore Company of Canada Ltd., Carol Lake, Labrador City, Newfoundland

SUMMARY OF SAMPLES EXAMINED AT CERL

Calendar Year 1985

	No. of samples	Estimated sample units
High explosives - Classes 1, 2 & 3	72	1440
Ammunition - Class 6.1	54	432
- Classes 6.2 & 6.3	17	136
Pyrotechnic mixes - Class 7.1	9	180
Fireworks - Class 7.2.1	164	164
- Classes 7.2.2 to 7.2.5	29	116
Miscellaneous	6	60
TOTAL	351	2528

PART II

MINERAL AND ENERGY TECHNOLOGY

ROCK MECHANICS LABORATORY

HIGHLIGHTS

In 1985/86 RML completed its first Index of Mining Technology Development report based on earlier surveys of the Canadian mining industry. A data bank system has been established to store all technical data gathered from surveys, and software developed to aid in the preparation of future yearly reports and to provide access to the data to respond to information enquiries.

Research and development of a mini-hydraulic scaler is now complete. The unit has been field-tested and is being marketed by Teledyne Incorporated, the contractor.

In line with MRL's objective of aiding small mines, advanced analytic ground control studies were carried out of key structural elements of the planned underground operations of Detour Lake Mine. A detailed report has been provided to the mine on the study.

Ore reserve evaluation studies were completed on two Southern Saskatchewan lignite deposits.

As part of the Canada/Manitoba Mineral Development Agreement, a state-of-the-art review on underground mine communications systems was completed. A mine communication system, has been selected on the basis of this study, for installation and testing in a Canadian mine.

SUB-SUB ACTIVITY: MINING METHODS AND EQUIPMENT

MINE METHODS AND EVALUATION

Project Leader: J. Pathak

Objectives

a) To prepare annually estimates of planned and projected production capabilities of uranium mines.

b) On a continuing basis to develop and evaluate mineability and mine operation economic criteria for hardrock mining situations in Canada, particularly with regard to existing and potential uranium mining operations.

c) By 1987 to develop a computerized mining cost database, cost models and mine evaluation procedures in order to carry out technical investigations to meet policy requirements.

Background

Engineering studies are carried out on an annual basis to determine the production capabilities and production costs of producing Canadian uranium mines. In addition, the future production capabilities and costs of Canadian properties are estimated. These studies are carried out in support of the Ore Reserve Evaluation Group and its preparation of an annual report for URAG.

To meet the above commitments it is essential for CANMET to acquire realistic production cost data in order to develop adequate mine operations evaluation procedures and to establish a base of unit productivities related to existing and developing mining technologies.

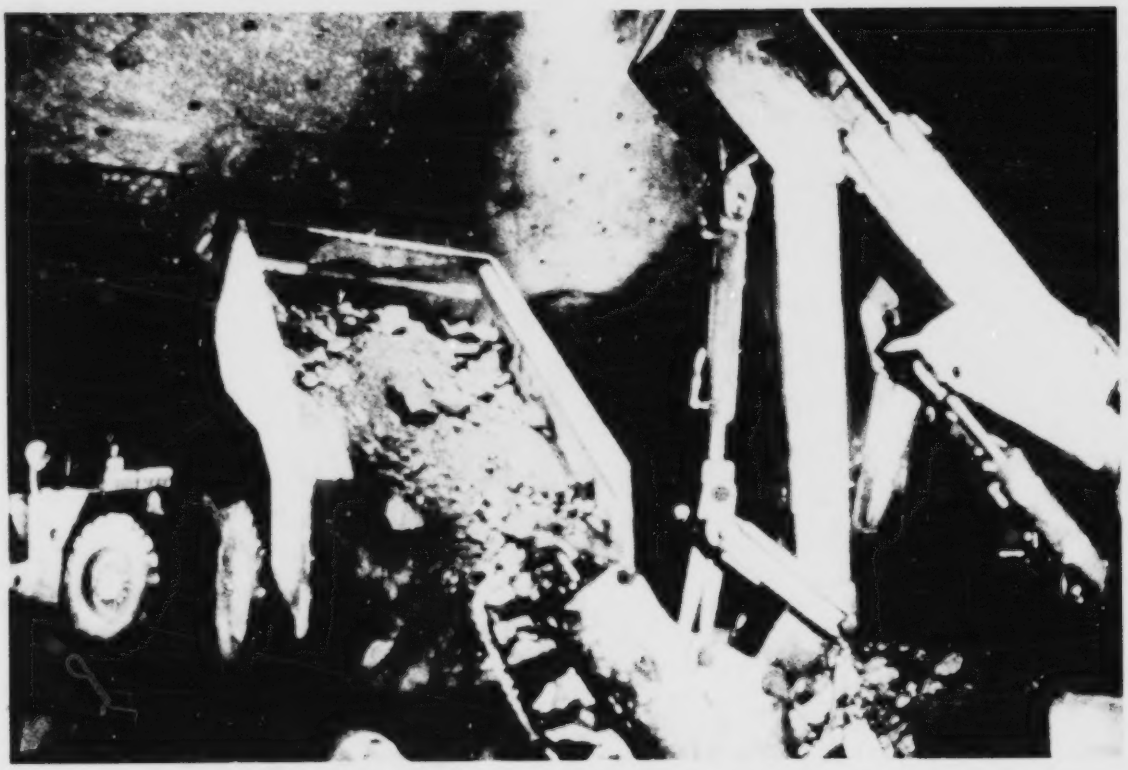
Such expertise, supported by the available databases, is applicable to all hardrock mining operations and is regularly used to carry out engineering studies on potential or existing mining operations to meet policy requirements.

Achievements

The major achievements for fiscal year 1985/1986 are outlined below:

1. Visits were made to all companies mining uranium or with well defined uranium deposits for the purpose of gathering technical information on mining in order to meet URAG information requirements.

2. A report outlining uranium production capabilities deposit by deposit was issued to the Ore Reserve Assessment Group during 1985.



- Truck Dumping into an orepass at Denison Mines Limited, Elliot Lake, Ontario

3. A contract on "Canadian Mining Industry Capital and Operating Indices" was completed. The study results will be used in the development of a mine cost model.

4. A contract study investigating the mining technology required and available to mine medium depth, high grade uranium deposits was completed by the contractor with preparation of a draft report. Further work is required before a final report can be prepared but the contracting company has gone into liquidation.

5. Good progress has been made on a contract to develop a manual to estimate the capital and operating cost of mining small mineral deposits by underground methods. It is expected that the contract will be successfully completed in 1986.

As well, a number of technical proposals and technology studies were carried in response to external requests: assessment of a gold mine project, inspection of a mine, evaluation of a proposal on the development of mine equipment, evaluation of a proposal on the development of new bit materials and evaluation of a proposal for the development of a borehole depth finder.

ROCK MASS CHARACTERIZATION

Project Leader: M. Bétournay

Objectives

The project has the following objectives:

1. to provide the Canadian Mining Industry with a handbook on surface crown pillars for safe and economic design, including guidelines for the design process;

2. to investigate underground stability where geological structure and gravitational forces are the major cause of failure; and

3. to develop empirical, statistical and deterministic models to predict stable structures.

Background

It is recognized that some specific structures in mining have special stability and support requirements. Surface crown pillars constitute a component of those mine structures requiring special consideration.

Special attention is required, to delineate the reasons for stability/instability of such structures and the best methods of retrieval of critical parameters, evaluation of stability and support requirements in the context of the operator's mining activity.

When properly included in a valid design approach, rock mass characterization provides the focus for dealing with surface crown pillars. Because of the uniqueness of these mine structures, in a material and comparitive sense, such characterization must employ methods and equipment used in the

Rock Mass Characterization

- Large open pit preparing for crown pillar and underground phase, Noranda Mines Limited

field of mining and civil engineering and would benefit from the availability of a surface crown pillar specific characterization system. Such a system would be applicable to large, multiple openings common in mining and would supply an understanding of how the rock mass interacts with support systems such as backfill.

Achievements

Research on various mine backfills is continuing at CANMET. Special surface crown pillar cases are being studied (laminated rock, Niobec Mine, Quebec; intensively weathered rock, Les Mines Selbaie, Quebec) which, when combined with the 24 completed case studies of Canadian surface crown pillars (located in Manitoba, Ontario, Quebec and New Brunswick) sponsored by CANMET, will provide a cross section of various rock mass settings and characteristics. Another service contract has provided CANMET with a computer based core logging system. This provides, potentially, one systematic method to establish a database for rock mass characterizations.

Design guidelines for safe and economic design of surface crown pillars were presented at the 88th annual general meeting of the CIM.

Identification of advantageous numerical modelling techniques and relevant publications are also complete.

ADVANCED MINE EQUIPMENT TECHNOLOGY

Project Leader: J. Pathak

Objectives

1. To assess the productivity impact of new world mining equipment developments and other developments in pertinent advanced technologies (i.e., robotics) on mining systems used in Canadian mines.

2. On a continuing basis, to conduct reviews of mine equipment technology and prepare state-of-the-art reports.

3. To plan, review and promote the development and demonstration of new mine equipment/equipment systems relevant to all aspects of mining.

Background

Improvements in safety and productivity often result from improvements in mining equipment. A good example, in this regard, is the replacement of separate loading and hauling equipment in mining by load-haul-dump units. The introduction of large hole drill machines in underground mining has permitted a reduction in the number of sub-levels required for drilling. Mine design has evolved in the past to accommodate and take advantage of new equipment developments. Further evolution will be required to take into consideration future equipment developments with respect to portable crushers, conveyors, tunnelling machines, pre-concentrators, etc.

Advanced Mine Equipment Technology

- Computer assisted design at National Research Council (NRC), Ottawa

Successful application of microprocessors, sensors, and data transmission systems to monitor and control production processes has revolutionized the manufacturing and processing industries. There is no reason to believe that elements of the above technology will not be successfully applied in mining.

Achievements

1. Test equipment has been developed under contract to test the viability of a cavitating hydro impactor. Initial laboratory trials established that available commercial high pressure water jet connections and seals did not have the strength to withstand transmitted rock hammer vibrations. Subsequently, new seals and connections were developed by the contractor which met requirements. They are the subject of a patent application. Field trials of the cavitating hydro impactor are planned for the summer of 1986.

2. Approximately 40% of a contract to develop the sensors required for automatic control of a down-the-hole drill (DTH) has been completed. Initial field trials on inclinometer sensors have been completed. On the basis of the results of these trials, housings for the inclinometers were redesigned which better suited a mine environment. Design of control system hardware has been completed and is presently being fabricated.

The recently developed underground blast simulation program has been rewritten for use with an IBM PC computer. The program's blast pattern design capabilities were demonstrated to MRL, Inco and Falconbridge technical personnel by the contractor. The program is presently undergoing field evaluation at Falconbridge Mines Ltd. by use in the design of 6 to 8 slash production blasts. Further evaluation of the program will take place in 1986 at Inco mines (Sudbury) by use in the design of VCR production blast patterns.

CANADIAN MINING TECHNOLOGY COORDINATION

Project Leader: J. Pathak

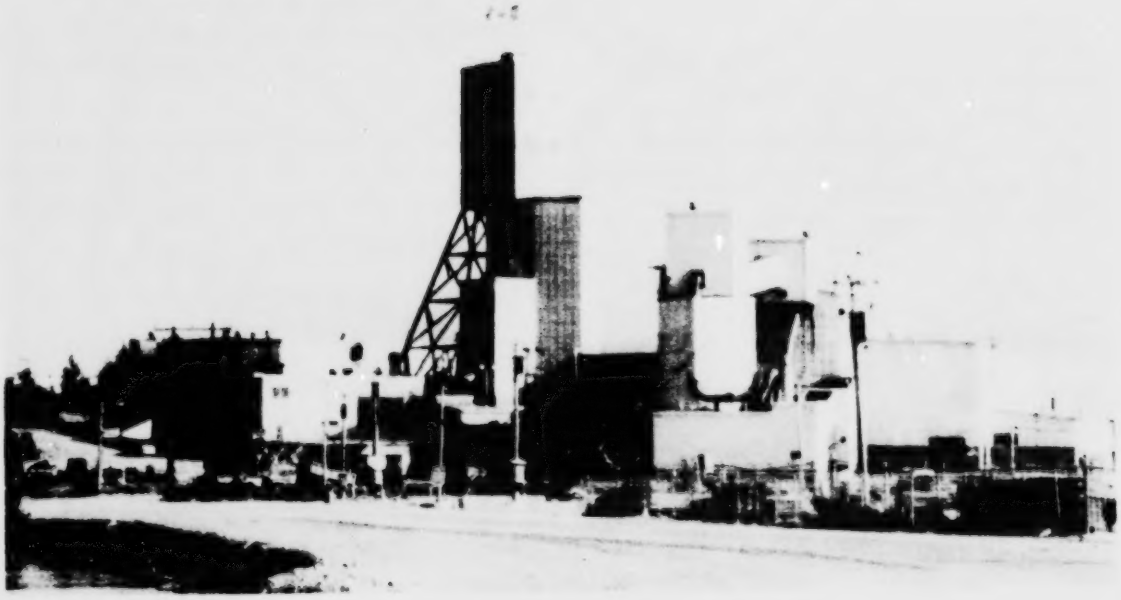
Objectives

To develop and maintain a national information bank on current and developing mining technology in the Canadian mining industry and other related organizations. The data is to be available to government and industry on a continuing basis. The ultimate objective is to promote cooperation and improve efficiency.

Background

There are many improvements in mining technology being developed on a continuing basis within operating mines, universities, government and other R & D organizations. Sometimes these developments, specifically intended for one particular organization and potentially beneficial to others, are never published. There appears to be a limited interchange of information on projects which are in progress and for which results may be available. An on-

Canadian Mining Technology Coordination



- PANEL mine surface plant and headframe,
Rio Algom Mines Limited, Elliot Lake, Ontario

going communications network assembling and disseminating such information would be a valuable contribution to mining technology development in Canada.

Achievements

The first CANMET Index of Mining Technology Development report was produced in 1985. It is available as CANMET Report SP85-12.

The report is based on survey material gathered from mining companies, government and public research agencies and universities up to December 1985. The survey is an on-going activity and it is planned to release annual index reports.

A computerized database was developed in 1985 which is now used to store and manipulate all index data. Future reports will be prepared directly from the database using software that has been developed for that purpose. Up-to-date reports will also be available on diskette.

MATERIALS HANDLING AND OPERATIONS RESEARCH

Project Leader: J. Pathak

Objectives

1. To develop new concepts for material handling systems for use in underground and open pit mines which provide improvements in productivity and safety.

2. By 1987, to develop new ventilation models for the determination of heat transfer in different media and mine segments.

3. By 1990, to develop mine simulation computer graphics packages for use in the optimization of various mine functions in mine design.

Background

The metals price depression of the 1980's has placed considerable pressure on the Canadian mining industry to maintain its advance in mine technology in order to remain competitive. Increased utilization of mathematical modelling and computer control can lead to more optimal usage of mine equipment such as trucks in open pit haulage operations. It has been estimated that successful automation and robotization of haulage trucks in a large open pit mine would result in a yearly operational saving of $150,000 to $200,000 per truck unit.

Achievements

1. Two reports have been prepared during 1985-1986: Division Report MRP/MRL 85-139(CF) on open pit transportation maintenance and Division Report MRP/MRL 86-27(CF) on an interactive data management system.

Materials Handling and Operations Research

- A massive earth moving project

EVAPORITE MINE METHODS

Project Leader: G. Herget

Objectives

1. By 1989 to increase potash recovery over current levels by carrying out contract research in the areas of ground control, environmental control and productivity.

Background

On May 17, 1983 the Minister of Energy, Mines and Resources announced the coming into force of the two (2) year START Program (Short-term Aid in Research and Technology) to assist the Canadian mining industry.

One of the thrusts provided for under START was research and development contracts with short-term industrial benefit. The current recovery rate of Saskatchewan potash is 40% and, though profitable, represents a significant loss of resources as well as profit due, in part, to increased underground transportation.

A two-year program of contract research under START ($250k/year) to aid the potash industry has been completed by MRL with the participation of the potash industry. A total of eight contracts which addressed questions of mine design ground control and dust monitoring were completed. Technology transfer is in process. The two-year program allowed undertaking a much needed initiative and the potash industry has responded very well.

Present studies, outside the framework of START, are directed towards monitoring excavation behaviour in potash under controlled conditions and predicting excavation behaviour by numerical modelling on the basis of material properties determined in field and laboratory studies.

In 1985 ground control research with respect to potash mining expanded into New Brunswick as part of the Canada/New Brunswick Mineral Development Agreement. This multi-year research program is directed at developing the technology/knowledge essential to use salt waste as a backfill material. If structural support provided by salt back fill proves effective, increased ore recovery can be expected.

Achievements

The following were accomplished in terms of objectives set for the year:

1. A report: "Seminar on Canadian Potash Mining and Ground Control" (MRP/MRL 86-1) was distributed which summarized all research contracts and achievements obtained under the two year START program.

2. A technology transfer seminar for the Saskatchewan potash industry took place on Nov. 14, 1985 at the Holiday Inn, Saskatoon. G. Herget and key

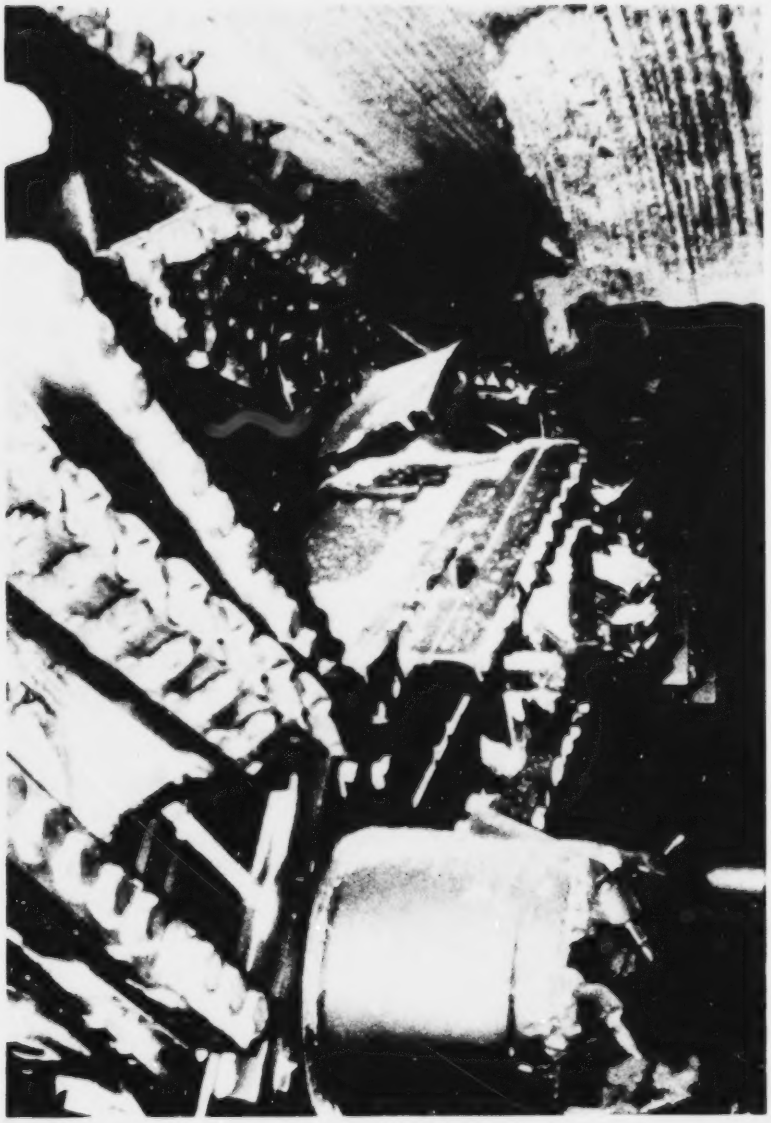
contractor personnel participated. Planning for two workshops on modelling of potash excavation, to be held in May 1986, was completed.

3. A new contract (1985/87) was awarded to COMINCO, Vansloy, Saskatchewan to numerically model excavation behavior using laboratory potash properties in order to compare model values with previously obtained field data.

4. A new contract (1985/86) was awarded to Denison-Potocan, Sussex, N.B. to establish the level of wall and roof support derived from backfilling mined out excavations with waste salt; the desired advantages from using salt backfill are higher extraction ratios and lower development and exploration costs.

5. Progress was made in an on-going review of underground potash mining methods with the purpose of achieving lower mining costs and greater predictability of water inflow. The mining company concerned is seriously contemplating a pilot study using shortwall mining.

Evaporite Mining Methods



- Potash Cutting Head

SUB-SUB ACTIVITY: ROCK MECHANICS

ROCK PROPERTIES AND SUPPORT SYSTEMS

Project Leader: M. Gyenge

Objectives

1. On a continuing basis, to establish the peak and residual strength, deformational and other rock properties required in ground control investigations.

2. By 1986, to produce rock bolting guidelines based on a code of design approach, and using the latest available technological data and analytical results.

3. By 1988 to produce laboratory test guidelines for use in underground rock mechanics investigations.

Background

An increasing portion of Canadian underground mining in the future will take place under high stress. Under such conditions, the post-failure strength and deformational properties of the rock materials must be taken into consideration in design.

Ground support requirements under deep mining conditions requires research. The effectiveness and limitations of present underground support systems need to be established. New methods of ground support must be developed.

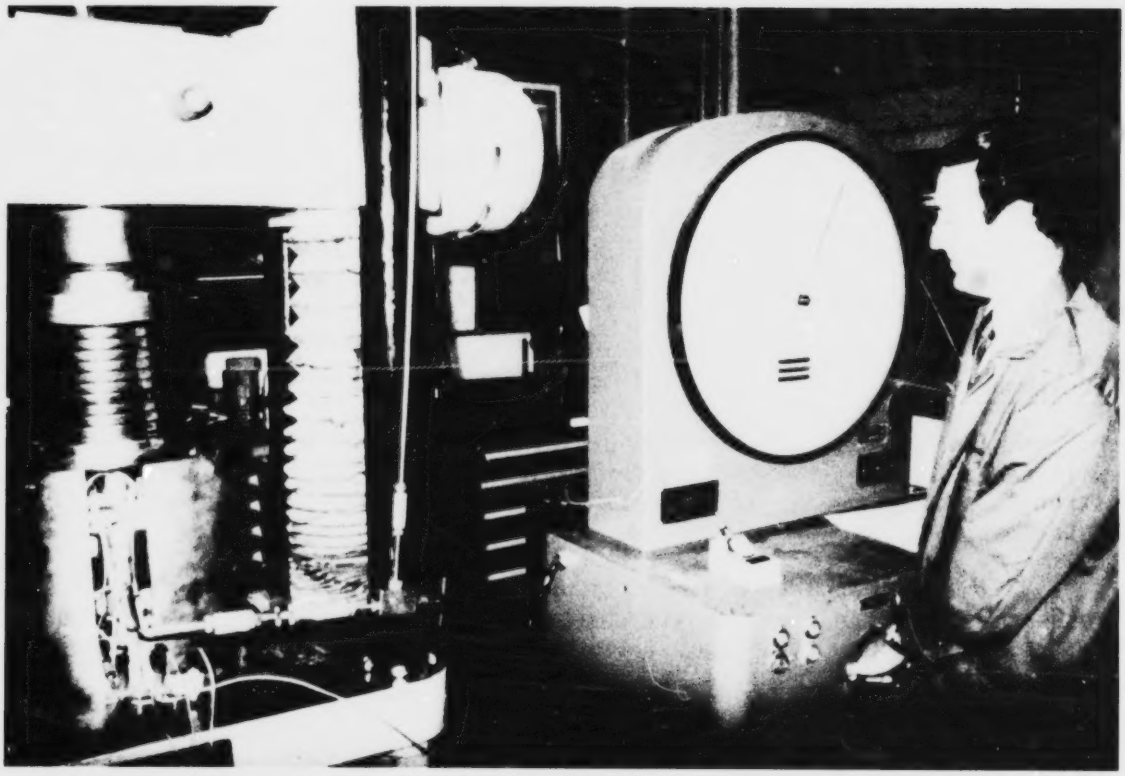
The increased accuracy and sophistication of analytic methods related to mine design, requires that more exact constitutive equations concerning rock strength and deformation properties be developed. New test methods and procedures must be developed to permit laboratory determinations of the required properties.

Achievements

1. The practicability of a previously reported shear test method based on a novel concept was fully verified in an additional test program. Final mechanical specifications for the equipment to carry out the test were established. Test data analysis and data presentation procedures and methods have been established for the test method.

2. Preparation of new rock bolting guidelines are well advanced. Drafts were prepared of the main volume and four supplements which comprise the guidelines. The main volume includes information in abbreviated form on recommended rock bolting specifications and rock bolt design charts. Detailed information is provided in the supplements on underlying rock bolt design concepts as well as on performance monitoring procedures.

Rock Properties and Support Systems



- Marc Bétournay performing a "stiff" test in RML, Building #10

The design guidelines have been developed taking into consideration the latest available technological data on rock bolt performance in Canadian mines.

NUMERICAL MODEL DEVELOPMENT

Project Leader: Y. Yu

Objectives

1. On a continuing basis, to carry out analytic numerical modelling studies as part of applied ground control investigations.
2. To develop numerical models and software packages for use by small mines on PC or micro-computers.
3. By 1987, to implement new computer models for evaluating the stability of underground openings and related mine structures.
4. By 1990, to upgrade software packages and hardware capabilities for mining and geotechnical applications.

Background

The prediction and evaluation of rock mass response to mining is becoming progressively more important in mine design and planning.

Information provided by such studies can be used by mine staff in the selection of mining methods, layouts, stope and pillar dimensions, and mining sequence taking more fully into consideration ground control and support requirements. Numerical models are finding increasing use in mining to predict ground response to mining and to evaluate the effectiveness of support systems. With time, the models are becoming more sophisticated and better able to simulate actual mine conditions in terms of mine geometry, mine sequencing and material properties. Further research leading to the development of improved models is required if mining is to fully benefit from this technology.

Achievements

1. In the area of computer applications, a general purpose finite element computer code for mining applications has been modified and implemented onto MRL's VAX/VMS system. The SAP2D system, including its pre- and post-processor have been upgraded and converted to run on MRL's VAX computer.
2. The first phase of a cooperative research project with Detour Lake Mines has been completed. It included determination of mine rock properties, determination of field stresses and numerical modelling of key mine structures for stability evaluation. As part of a cooperative research project with Niobec Mine, a three-dimensional F.E. Model study to evaluate stope stability has been initiated which will continue into 1986/87.

Numerical Model Development

- Student inputting rock strength data for modelling

3. Efforts are continuing to upgrade MRL's VAX/VMS system and hardware capabilities for mining applications. The VAX/VMS system has been brought up to 4.2 level and upgraded to 5 MB of memory. A Calcomp 1042 plotter was installed and made operational. A Gandalf PACX 2000 communication system was installed which facilitates communication with other VAX/VMS systems and the departmental computer. To assist MRL's development of graphics packages for mining, a Sun Microsystems 3/160C workstation was acquired and installed.

UNDERGROUND NUCLEAR WASTE REPOSITORY

Project Leader: A.B. Annor

Objectives

1. The general objective is to develop, by 1989, field and laboratory investigational methods, equipment and procedures to assess rock formations for high level radioactive waste disposal in terms of their thermal, mechanical and ion transport properties and to carry out related investigations on research area formations and at the planned underground research facility site. The studies carried out in research area formations and the underground research facility site will be used in pathway analysis studies related to concept assessment and in the design of the underground facility.

Background

Disposal of spent fuel rods will become a critical aspect of nuclear electricity generation. EMR's program is an integral part of a larger Atomic Energy of Canada Limited's (AECL) directed Canadian Nuclear Fuel Waste Management Program (NFWMP) to find safe and effective methods of disposing high level nuclear wastes.

The current participation of EMR in the NFWMP has evolved over the past ten years from an initial request in 1973 from AECL to EMR for geoscience advice on disposal by burial. An integrated geoscience sub-program has since been developed at EMR in support of NFWMP with current active participation by CANMET, Geological Survey of Canada (GSC) and Earth Physics Branch (EPB). The sub-program is structured into geology, geophysics and rock properties activity and is mainly focused on igneous formations.

At present, four research areas on plutonic structures located in Manitoba and Ontario are being used to investigate the concept of disposal of high level nuclear waste by burial. As well, an underground research laboratory (URL) is under construction near the Whiteshell Nuclear Research Establishment (WNRE) in Manitoba to carry out large-scale underground experiments.

Achievements

The following were accomplished in terms of set objectives for the year:

Underground Nuclear Waste Repository

- Extensometers placed underground to determine rock movement (URL), Pinawa, Manitoba

Fragmentation

- Excavation trials to optimize explosives quantities and distribution

1. A large scale direct shear equipment was constructed to study the effect of scale on rock joint behaviour. Study results using this equipment are essential for relating laboratory small scale rock joint behaviour to in situ rock mass conditions.

2. Comprehensive reports were also prepared detailing newly developed methodologies and equipment. Reports were also prepared on thermomechanical investigations of rock samples from various NFWMP research areas. The latter reports will contribute to final documentation for assessing the deep burial concept of waste disposal.

INSTRUMENTATION DEVELOPMENT

Project Leader: G. Herget

Objectives

To develop and test field geotechnical instrumentation, specifically:

1. by 1986, to develop and test a universal borehole installation tool;

2. by 1987, to develop and test a rugged, small, side-viewing borehole T.V. inspection tool and a forcemeter to determine the stability of bulkheads in backfilled stopes;

3. by 1987, to complete organizational duties for the ISRM Congress in Montreal;

4. by 1988, to develop and test a borehole deformation tool to determine in situ modulus and stress in soft rock; and

5. by 1990, to develop and test a locator for brine in bedded potash deposits.

Background

A wide variety of geotechnical instrumentation has been developed over the years for use in mines but very little objective testing and field evaluation has been carried out. Because of MRL's access to mines and its expertise, MRL is in an excellent position to evaluate such instrumentation in terms of performance criteria and usefulness.

There is also a need to develop several new instruments/instrument systems for use in ground control studies related to mining including the following: a small diameter borehole inspection T.V. camera for stability evaluation and design, force meters for blast vibration studies and meters to determine the in situ creep/deformation properties of potash. MRL can very effectively participate in the development of such new geotechnical instrumentation for the mining industry.

Instrumentation Development

- Testing of side-viewing borehole T.V. camera in a brine filled borehole

Achievements

The following objectives were accomplished during the year:

1. A universal borehole installing tool was developed and successfully tested in an underground environment during ground stress determinations measurements.

2. New software was written for the South African doorstopper stress determination method.

3. Work was commenced on modification of a small, sidelooking, borehole TV camera for use submerged in salt brine.

4. A new vibrating wire stress monitoring unit is under development and construction.

MANITOBA MINERAL DEVELOPMENT AGREEMENT

Project Leader: C.B. Graham

Objectives

1. By 1989: to develop Vertical Block Method (VBM) design guidelines which include relevant parameters such as stope and pillar dimensions, optimum locations of drifts, mining sequences, ground support and fill requirements; to develop safer procedures for scaling loose rock in roof/hangingwall associated with the VBM method; to develop a geotechnical database and numerical package for the design of underground openings at depth; to develop ground stability evaluation criteria with particular reference to an en echelon lensed orebody, and; to select and install in an underground Manitoba mine a communication system utilizing existing technology and evaluate its economic and technical feasibility.

Background

Cut-and-fill mining is used extensively in northern Manitoba. However, when used in poor ground conditions, serious production and safety hazard problems can be realized. With this method, miners must work directly under ground with caving potential. Because present cut-and-fill mining requires extensive scaling, heavy support, blast control and skilled labour, modified or new methods such as VBM methods are being investigated for replacement potential.

Improved ground control also requires a better understanding of rock mass response to mining and the causes of instability. Therefore, studies in the area of rock mass behaviour, mine stability, numerical modelling and improved mining technology are planned.

Safety in underground mines would benefit from the availablity and use of more effective radio communication systems. Warning systems for fires

based on the injection of stench gas in the mine air are inadequate for working areas which receive limited ventilation. A reliable communication system will be installed and evaluated which will permit mine-wide voice contact with personnel.

Achievements

1. Four of the six mineral development agreement tasks were under contract in Manitoba mines in 1985/86.

2. The most widely acclaimed achievement was the state-of-the-art review of mine communications systems which included a pilot installation proposal. The entire mining industry reacted very favourably to the report. The pilot study has been accelerated and expanded to include data as well as voice transmission.

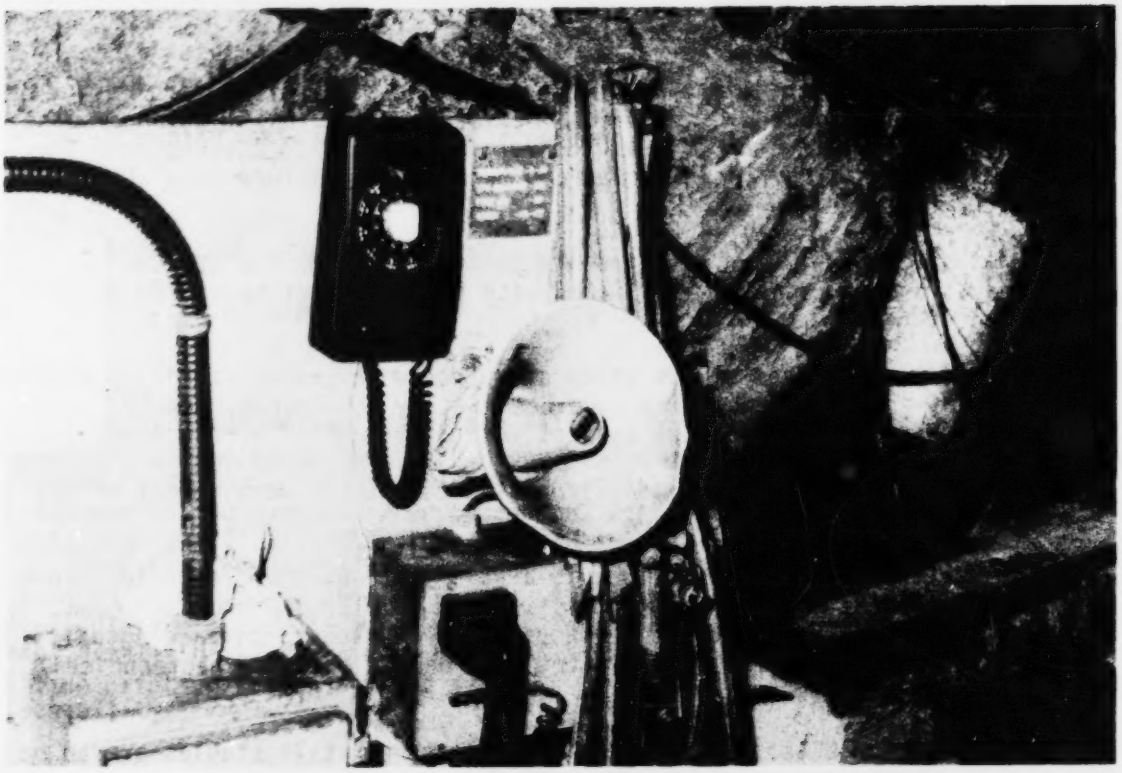
3. Trial stopes have been selected and instrumented for the VBM design study. Scaling studies associated with the VBM study have been delayed until 1986/87.

4. All early objectives of the study concerned with ground stability evaluation of en echelon deposits have been met by contractor, namely: review of rock mass classification systems, establishment of a rock mass database and instrumentation of a test stope. The contractor is now in a position to proceed with numerical modelling studies and the development of design guidelines.

5. The geotechnical database study is a full year ahead of schedule. Background studies have been completed and the modelling phase has begun. In the coming year, selected mine stopes will be used to compare actual ground conditions with those anticipated on the basis of geotechnical/ modelling studies.

Contracts for blast optimization and delayed backfill studies are to be awarded in the coming year.

Manitoba MDA (Mineral Development Agreement)



- A "traditional" communications system is shown in an underground mine

Ontario MDA (Mineral Development Agreement)

- Kidd Creek Mines Limited (Timmins, Ont.) uses modern backfill technology which is a major thrust of the Ontario MDA

SUB-SUB ACTIVITY: MINERAL RESERVES ASSESSMENT

URANIUM RESERVES

Project Leader: Á. Füstös

Objectives

1. To determine and report annually on Canada's economically mineable uranium reserves and inferred resources;

2. to determine the ore reserves of specified mineral deposits to meet departmental information requirements; and

3. to develop new ore reserve evaluation methodologies for the assessment of mineral reserves and related economic values.

Background

In 1974 the need for an expanding role for nuclear power in Canada was recognized. Accordingly, a policy was initiated to encourage exploration for uranium in Canada. In addition, the Uranium Resource Appraisal Group, (URAG), was established with the mandate to maintain a continuous, reliable and uniform assessment of Canadian uranium reserves, resources, and productive capability, as a basis for the nuclear related aspects of the government's energy policy. In support of URAG, three departmental sub-committees were created: the Sub-committee on Reasonably Assured Resources (measured and indicated reserves); the Sub-committee on Estimated Additional Resources (inferred, prognosticated and speculative resources); and the Sub-committee on Economics of Supply and Demand. The Ore Reserves Assessment Group, (ORAG), established within the organization of the Mining Research Laboratories, is responsible for leadership of the Sub-committee on Reasonably Assured Resources and participates in the work of the other two sub-committees.

Since its inception in 1974, ORAG, on behalf of URAG, has assembled primary assaying and sampling data on relevant uranium deposits on a continuing basis. At the same time its staff has developed required procedures for computer storage of the assembled data, as well as a variety of computer-applicable assessment methodologies for evaluation of mineral reserves and resources. ORAG produces a major internal confidential report annually, which contains the current status of reasonably assured reserves of uranium and associated inferred resources of thorium in all developed deposits in the country, regardless of whether or not these are actively producing or dormant. The report also contains the actual, or estimated projected production capabilities of these deposits.

Since 1982, ORAG also utilizes its accumulated expertise and its already developed computer-based resource assessment methodologies to evaluate annually one or more Canadian coalfields, where the necessary primary sampling data exist to assess coal resources. This latter activity is carried out in cooperation with the Coal Research Laboratory.

Achievements

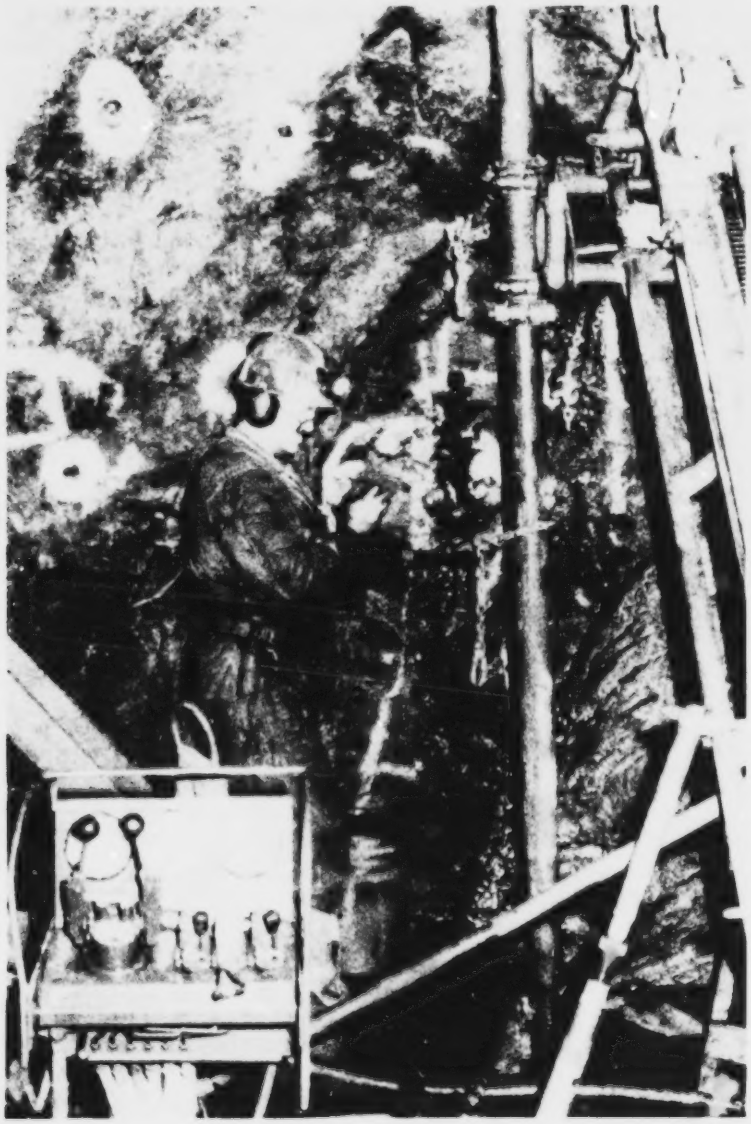
1. During 1985/86, ORAG prepared its internal confidential report on the "Reasonably Assured and Associated Inferred Resources of Uranium and Inferred Resources of Thorium in the Major Deposits of Canada 1984", [Division Report ERP/MRL 85-74(CF)], and submitted it to URAG. In addition, it collected the currently accumulating primary sampling and assaying data from active uranium mining and development companies. The collected data are being utilized in the current preparation of ORAG's next internal confidential report on uranium for 1985.

2. Both the in situ and recoverable reserves and resources of a Saskatchewan coalfield were also evaluated in 1985/86 by ORAG. The results of this latter activity were summarized in two reports, entitled: "Assessment of Recoverable Coal Reserves, Wood Mountain Coalfield, Saskatchewan", [Division Reports MRP/MRL 85-133(TR) & M&ET/MRL 86-43(TR)].

3. During the year, the staff of ORAG compiled a bibliography of all non-confidential reports, prepared by its members entitled: "Bibliography of Non-Confidential ORAG Reports from 1975 to August, 1985", [Division Report MRP/MRL 85-107(TR)].

4. In the context of its computer-centred activities, ORAG staff tested the CADD/GEM software conversion carried out by Borealis Corp. of Saskatoon, Sask. In the framework of technology transfer between ORAG and the Uranium Resource Evaluation Unit of the Australian Bureau of Mineral Resources, Geology and Geophysics, ORAG transferred a complete deposit database and its treatment by eight ORAG computer programs to their computer system.

Mineral Reserves Assessment



- Diamond drill underground developing new reserves, Ruttan Mine, Sherritt Gordon Mines Limited, Leaf Rapids, Manitoba

CANADIAN EXPLOSIVE ATMOSPHERES LABORATORY

HIGHLIGHTS

The activity in the certification and testing of equipment and materials for underground mines was twice that of the previous year reflecting a mood of optimism in the suppliers to the mining industry. The extra load on CEAL's certification and testing staff has resulted in a substantial backlog of work. In addition, extensive renovations to the laboratory facilities has temporarily aggravated the situation because we have had to reduce our testing activity during the last quarter to allow the contractors to proceed with the renovations.

The laboratory renovations currently underway are expected to be completed near the end of the first quarter of 1986/87. This will substantially improve the efficiency of the testing because we will now be able to test simultaneously in several areas.

In the standards work, the conveyor belting standard has finally been approved by the technical committee after several years of work in both the committee meetings and the laboratory. This work was complicated by rivalry between two different technologies, PVC and rubber belting, but the end result is a substantial upgrading in the fire resistance of EMR certified belts. A new draft standard for fire resistant mine duct material has been prepared by CEAL staff and it is expected that a new technical committee will be set up shortly.

In addition to the new standards work, several existing certification standards were revised to improve the safety aspects or to keep up with changing technology.

CEAL scientists were involved in the field testing of three diesel emission reduction technologies under actual underground mining conditions. Extensive research had been done previously on two of these technologies at CEAL and the most promising one (the ceramic filter) is currently being transferred to industry. Two CANMET sponsored seminars on the Air Quality Index developed under contract by Ian French and Associates were well received by the underground mining industry.

SUB-SUB ACTIVITY: COAL MINING SAFETY CERTIFICATION

EQUIPMENT SAFETY CERTIFICATION

Project Leaders: J.A. Bossert and G. Lobay

Objectives

1. To provide, on a continuing basis, a national service for the certification and quality assurance of flameproof equipment, gas detectors, and fire-resistant materials to be used in explosive atmospheres of coal mines and other dangerous industrial environments.

2. To develop appropriate new standards to meet changing conditions in industry.

Background

In 1953, the federal government established a laboratory for equipment safety certification, on a cost-recovery basis, of coal mine electrical equipment for use in explosive underground environments. This original mandate has evolved slowly over the years concurrently with developments in coal mining technology to include numerous fire-resistant materials and fluids, diesel machinery and explosive gas detection equipment in both underground and industrial hazardous locations. Research efforts to improve the quality of both the certification service and the standards utilized as the basis for such certification continues.

Thorough research of risks and safety requirements in advance of establishing standards is needed. Thus, the laboratory must anticipate equipment, materials and mining developments years in advance to ensure that appropriate standards are available. The advent of more complex robot-like mining equipment, and underground mining in oil sands are future areas currently being considered.

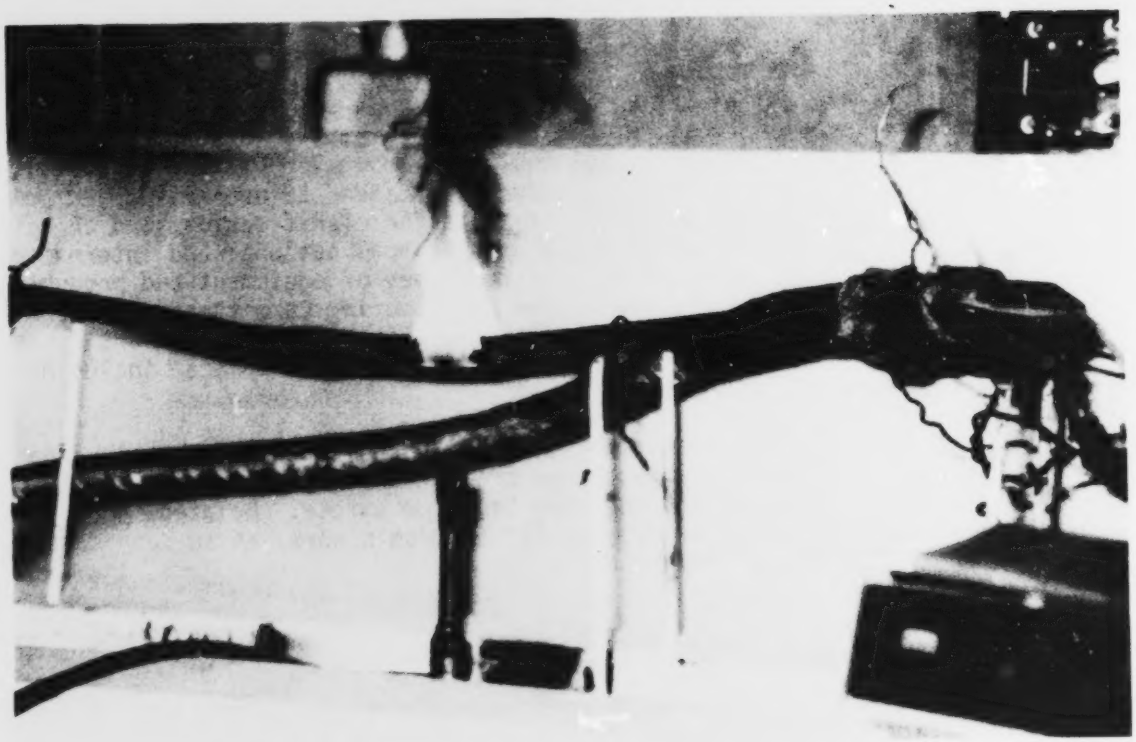
A new thrust, that of quality control follow-up by inspection, is being currently developed. This involves in-house effort, coupled with the inspection staff of CSA, in accordance with an agreement signed in early 1984.

Achievements (Safety Certification)

Despite a general decline in the Canadian underground coal mining activity, a total of 97 certificates were issued this year, which is more than double the number issued last year. The increase appears attributable to two factors; first, the growing interest of non-coal mines in EMR certified fire resistant and other products, and second, the importance to users of implementing new, efficiency-improving or otherwise technically superior products which must first be certified.

Illustrating the range of products certified, a fleet of diesel powered personnel carriers for use in Canadian potash mines was among the

Equipment Certification and Testing



- A combustion test on mine power cable
(Explosive Atmospheres Laboratory -
Building #9 - CANMET/MRL)

largest, with a transcutaneous electrical nerve stimulator (designed to be worn by a coal miner for chronic pain relief) among the smallest.

This increased certification activity also appears to be sustained into the new year, and includes a number of applications for certification of products destined for a demonstration underground tar sands extraction project in western Canada.

The transfer of all certification records (over 800 files) to a computer database has been completed successfully, allowing the annually published list of certified products to be generated automatically by the database software.

Standards activities continue to be important, with staff participation in the development of the diesel equipment, conveyor belting, and blasting machine draft documents. Many standards continued to be revised and updated in response to new information, requests for clarification, and changing technology. In addition to participation in several national and international standards committees relating to specific types of equipment and products, the laboratory is also represented on the CSA Steering Committee for Electrical and Mechanical Mine Safety and the Canadian Electrical Code - Part I, each of which is more generally involved with safety in the workplace, including explosive atmospheres.

Participation in all standards work is predicated on the relevance of the activity to explosive atmospheres or flammability of materials with the major benefit aimed at, and accruing to, mine safety. Related industries (petroleum, chemical, natural gas) benefit from this work, as in many cases parallel hazards to the workplace exist.

Achievements (Safety Testing)

The safety testing project is primarily intended as a backup for the safety certification project, but contract testing is also performed for outside agencies and Canadian companies.

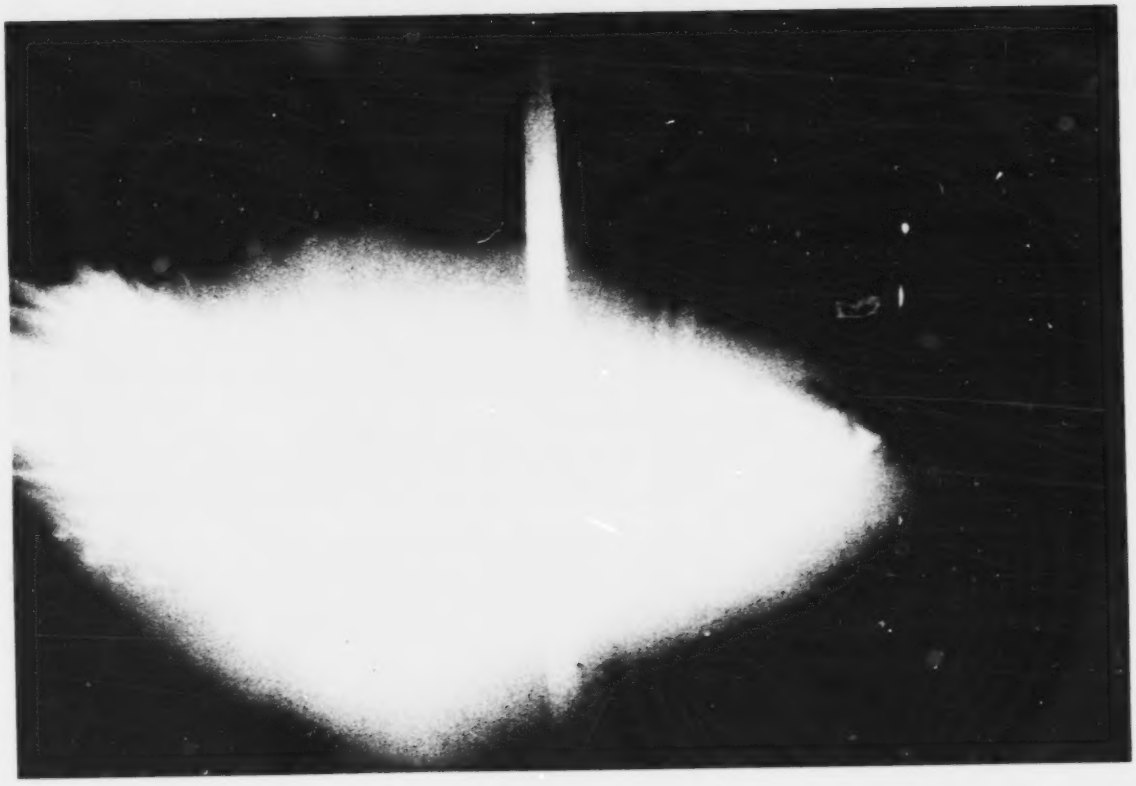
Contract testing work is accepted only on the basis that the equipment tested has an immediate application in Canada and consequent benefits for the Canadian workplace, or on the basis that the testing will provide benefit to a Canadian industry. With reference to the latter criterion, CEAL test reports have been used on an acceptance basis by other certification agencies.

Contract testing activity included 27 projects being undertaken on behalf of the Canadian Standards Association, as well as 33 projects being undertaken on behalf of other Canadian companies or agencies. These figures indicate a somewhat reduced number of projects, relative to the previous year.

Standards Development

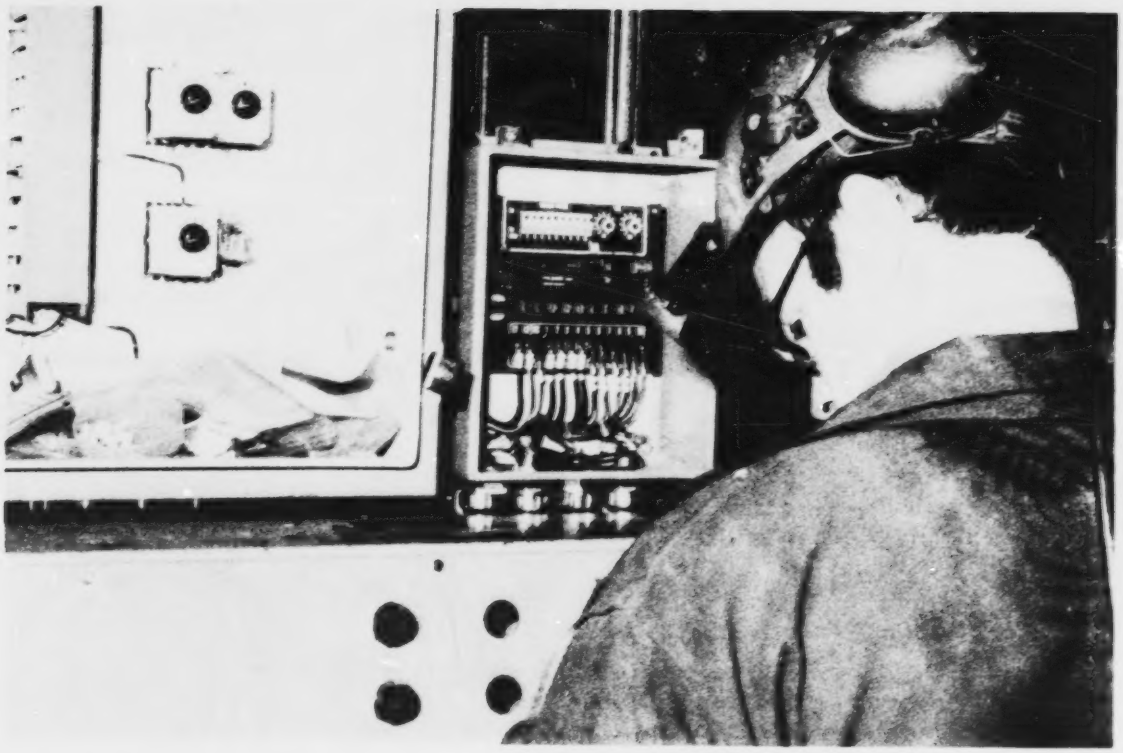
The laboratory facilities and equipment have been substantially modified to implement the much more stringent requirements of the new standard

Standards Development



- Hydraulic fluid under test to establish appropriate standards (Explosive Atmospheres Laboratory - Building #9 - CANMET/MRL)

Quality Assurance



- Electrical installation underground at Ruttan Mine, Sherritt Gordon Mines Limited, Leaf Rapids, Manitoba, using certified components.

for fire-retardant conveyor belting, which is due to go into effect shortly. Long-term tests have shown that the flame test is unsuitable as a quality control tool, but that the critical oxygen index (COI) test remains constant. Round-robin tests on COI tests are underway with manufacturers; the first results are encouraging.

An interim large-scale test for brattice cloth and rigid ventilation tubing has been implemented to supplement the existing small-scale tests which are not sufficiently strict for all types of materials. A draft for a standard for fire-retardant ventilation materials has been written, which will be presented to a CSA technical committee when it is formed.

Work is continuing in the development of a Standard for fuel burning appliances for use in hazardous locations.

DIESEL FLAMEPROOF AND EMISSION R&D

Project Leader: E.D. Dainty

Objectives

To develop and encourage the adoption of technology for the improvement of the quality of the underground environment, specifically:

1. by 1986 to demonstrate diesel emissions toxicity devices underground; and to evaluate methane, diesel contaminant, ventilation and spontaneous combustion sensors for use in continuous mine monitoring systems;

2. by 1988 to finalize the form of the Air Quality Index expression for ventilation prescription and environmental assessment; and

3. by 1989 to complete a monograph on diesel emission reduction and environmental assessment.

Background

Since 1970, the Canadian Explosive Atmospheres Laboratory (CEAL) has undertaken health and safety R & D in connection with the use of diesel machines in underground coal and non-gassy mines. This work has involved four major thrusts:

1. the development of a mathematical expression which characterizes the toxicity of undiluted diesel emissions and the quality of ambient mine air, called the Air Quality Index (AQI);

2. the development of exhaust treatment hardware to reduce the toxic concentrations of diesel exhaust;

3. the assessment of the quality of the air in underground Canadian mines by the deployment of portable analysis equipment for the measurement of toxic emissions, polynuclear and aromatic hydrocarbons, and Ames mutagenicity;

4. the synthesis of the principles established into strategies which have the potential to reduce ventilation costs; improve environmental quality and increase productivity, improve visibility depending on the circumstances; and permit an engineering approach to equipment selection and dieselized mine design.

Since 1981 this work has been undertaken jointly with the United States Bureau of Mines and the Ministry of Labour of Ontario. The memorandum of Understanding covering this collaborative work is designed to end in June 1987.

An IRAP/PILP agreement is being undertaken to transfer the emissions reduction technology to a private sector firm beginning in 1986 and ending in 1989.

Achievements

This work incorporates three main areas: (a) diesel emissions control, (b) health impact R & D, and (c) environment monitoring. Much of the work in these areas was completed in 1985-1986; residual amounts of technical and scientific work remain for the following year and a vigorous program of technology transfer is to begin in 1986.

a) Diesel Emissions Control

By in-house investigations, field tests and contracted-out research and development studies, much progress has been made in the development of venturi water scrubbing, ceramic filter, 100% methanol engine and the catalytic trap oxidizer.

The recirculating venturi water scrubbing system was assembled in the laboratory and dynamometer-tested. The wet type soot filter, developed previously, functioned well and the measured soot removal efficiency proved to be a healthy 70%. These systems were sent to the Ontario Research Foundation (ORF) for independent performance evaluation; the in-house results were confirmed. The equipment was then adapted to a Jarvis Clark RX500 LHD and shipped to the Michigan Technological University underground mine laboratory for environmental impact assessment. The preliminary results have confirmed that the venturi performance approaches that of the ceramic filter, suggesting that this system is a useful option for coal mines, particularly where LHD machines are used for production purposes, and where a limit of soot plus coal dust of 2 mg/m^3 is imposed limiting production, as in U.S. jurisdictions. A potential export market for Canadian machines so-equipped has become a possibility.

The ceramic filter has undergone further tests at ORF involving fuel additives and two types of catalyst: noble and non-noble. The manganese additive tests have shown that the trapping of the manganese is equally efficient as the trapping of soot, i.e., 90% ±. This is positive and important from a manganese toxicity point of view. Both catalyst types have indicated that sulphur dioxide conversion to sulphuric acid is minimized (an important positive result). Ames mutagenic assessments have yet to be performed (early in 86/87). It is likely that these catalyzed options will prove to be the best filter options to emerge from the stand point of passive unattended operation for the widest range of applicability.

Extensive underground durability tests of a pair of 'unassisted' ceramic filters in an operating production LHD machine at INCO's Little Stobie Mine, have reached the 1892 hour point. These were removed and sent to ORF for damage and performance checks. The pressure differential and filtration efficiencies have not deteriorated during this rugged service, confirming that the ceramic filter is a rugged, viable strategy for significant diesel emissions reduction in mines. Arrangements are underway to transfer this technology to Engine Control Systems in Aurora, Ontario via a 3-year IRAP/PILP agreement.

Off-shore oil supply interruption is again emerging as a possibility. In which case, the 100% methanol engine study could be very significant for the mining industry because methanol can be produced domestically and the expected toxic emissions from modified diesel engines are low in comparison to standard diesel emissions. Unexpected high levels of soot encountered in trials during dynamometer emissions mapping at ORF have been corrected and the 100% methanol low-emissions engine has been mounted in an INCO LHD machine for underground trials in 1986-87.

The catalytic trap oxidizer (CTO) produced by Engine Control Systems has been evaluated under an unsolicited proposal study at ORF. This unit has shown a minimum of sulphur dioxide conversion to acid and a very low mutagenic response - very positive characteristics. One version tested removed 60 to 70% of the soot generated by the engine, modestly reduced the soot ignition temperature from 500°C (932°F) to 417°C (783°F), and produced a back pressure rate of increase of 0.25 kPa/hr in a non-regenerative mode. Further development is needed to reduce this back pressure buildup rate and improve the soot regenerative threshold.

b) Health Impact R & D

Excellent correlation between laboratory and underground levels of mutagenic activity have been achieved for untreated diesel exhaust and exhaust treated by a variety of novel and existing emission control options. While mutagenic activity is not an absolute measure of cancer risk, it does permit ranking in terms of risk from lowest to highest as follows: ECS/JM CTO, Corning filter, venturi scrubber, untreated exhaust, monolithic catalyst, pelletted catalyst.

Dr. David Muir, Director of the Occupational Health Program at McMaster University has examined the world's literature on health effects of exposure to polynuclear aromatic hydrocarbons (PAH). Comparing this with PAH levels in a number of Canadian underground dieselized mines (assayed under previous CANMET contracts), he concludes "the evidence thus suggest that the underground PAH's are undesirable, that efforts should be made to reduce them but that the health impact as far as lung cancer is concerned is likely to be small".

Mutagens responsible for the huge increase in mutagenic activity observed when pelletted purifiers are fitted to diesels were not able to be identified, as the samples (in contrast to five previous sets) did not exhibit high levels of activity. This was likely due to excess engine load caused by two ramps at the sampling site. It is hoped to repeat the sampling, possibly in a laboratory setting, to tie up this final loose end in the mutagen program.

c) Environment Monitoring

The final detailed metal mine environment assessment of a series of three, was completed at the Brunswick mine near Bathurst New Brunswick in December of 1985, by a CANMET/MRL team in collaboration with mine personnel. Sampling stations were set up to monitor the background, return air and LHD vehicle operator exposure levels of four toxic gases and respirable particulate matter (soot) in order to assess the individual levels and determine the level of the Air Quality Index (AQI). Of the 18 separate measurements at all three mines that were made, only 2 were such that the AQI exceeded the suggested limit of 3 and none of the individual constituents exceeded its TLV or other appropriate limit.

This monitoring effort was extensive and significant. The highlights have been reported in "A summary of underground mine investigations of ceramic diesel filters and catalytic purifiers" [M&ET/MRL 86-20(OPJ)] to be presented to a special session of the CIMM/AGM in Montreal May 14/86. Much of this work however will be further reported in 86/87 and subsequent years.

These detailed field underground environmental quality assessments of unassisted and additive-assisted ceramic filters relative to catalytic purifiers have shown:

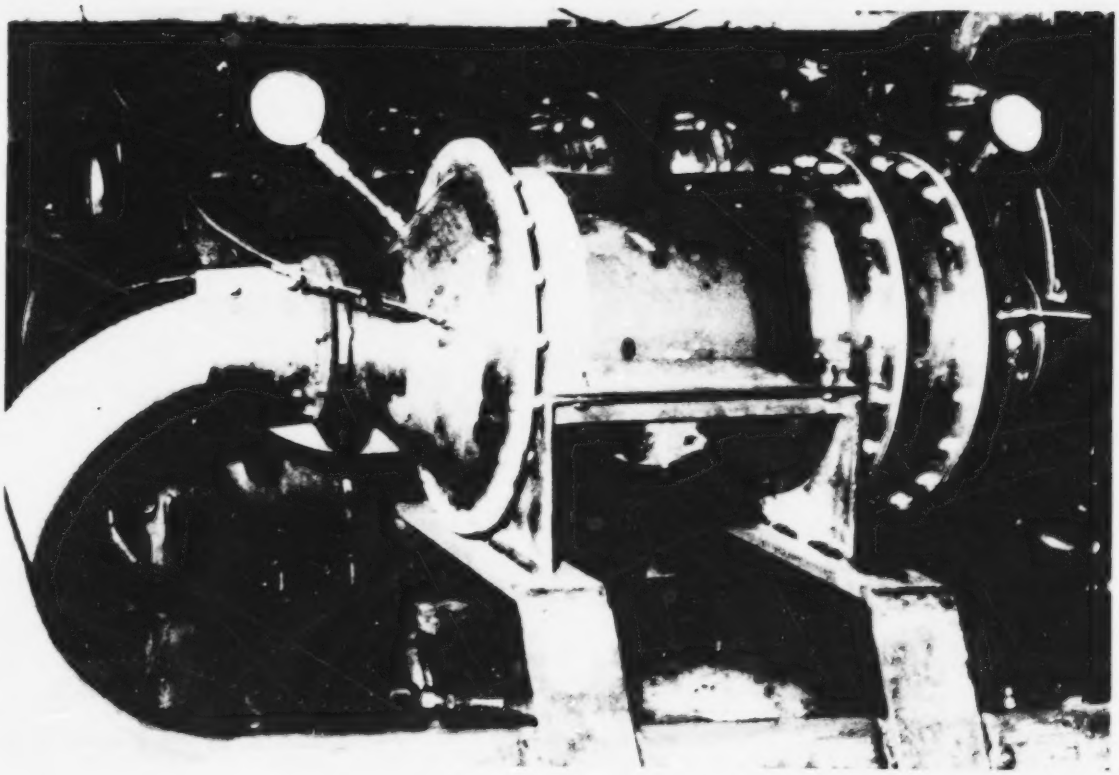
a) significant, measured reductions in the toxicity of the underground environment of the order of 45% for unassisted filters (higher for the additive case), relative to catalytic purifiers in widespread use;

b) that care must be taken in the interpretation of diesel soot as measured by respirable combustible dust (RCD) sampling. The absence of air-borne drill mist, evaporated oil leakage from hot surfaces, and a combustible component in the air-borne ore dust, suggests greater environmental improvements than is apparent from measurements in the real-world where one or all of the above materials may substantially reduce the measured efficiency of the filtration process;

c) that, as an approximate guide for normal functioning equipment in similar circumstances to those studied, maximum CO_2 levels of 0.09, 0.15, and 0.25% as measured at the operator's station for catalytic purifiers, unassisted DPFs and additive-assisted filters respectively, control the AQI at its maximum level three respectively (assuming fuel sulphur levels of 0.2% or less, and a clean air background), and;

d) that the general levels of gaseous and particulate contaminants, and the Air Quality Indices for LHD operation in the environments of the Canadian metal mines studied, are generally well below the levels equivalent to an $AQI_{max} = 3$ and the individual constituent ACGIH or other appropriate TLVs, when the order of ventilation rates quoted are furnished. This suggests that significant ventilation savings may be possible if filter technology is applied.

Diesel Flameproof and Emission Research and Development



- A ceramic filter for emission reduction in diesel exhaust operating on a scooptram at INCO Limited, Sudbury, Ontario

SUB-SUB ACTIVITY: EXPLOSIVE ATMOSPHERES

FIRE AND EXPLOSION HAZARD R&D

Project Leader: K.J. Mintz

Objectives

To encourage the development of improved equipment and materials to reduce risks to the safety of underground miners and other workers due to the presence of explosive concentrations of gas, vapour or dust, specifically:

1. By 1986, to develop a more valid method of measuring the minimum ignition energy for dust explosions;
2. by 1987, to develop a method for evaluating the thermite reaction hazard resulting from impact on light alloys;
3. by 1987, to commission a larger-scale dust explosion apparatus;
4. by 1988, to commission a new apparatus for measuring the electrostatic hazard of materials;
5. by 1989, to complete a study of sulphide ore dust explosions and the means to reduce or eliminate them.

Background

Explosions of gas and dust occur regularly around the world in coal mines, flour mills and other hazardous industrial locations, causing significant loss of life, injuries and material damage. For example, in 1985, a miner died in a Canadian mine from breathing sulphur dioxide which had been produced by a sulphide ore dust explosion. Better understanding of the gas and dust explosion phenomena can lead to improved technologies to eliminate or reduce the hazards.

Achievements

The new, more valid, technique for measuring the minimum ignition energy of dust explosions, which involves both improved instrumentation and methodology, is in the process of being finalized.

The interfacing of the image analyzer and a microcomputer has been debugged and is ready for further software development, with the aim of determining the effect of particle shape on dust explosion parameters.

The experiments on minimum explosible concentration, maximum explosion pressure and rate of pressure rise of DEVCO coal dust/methane mixtures have been completed.

The third phase of a contract study by McGill University on dust/air explosions has been completed. The major findings are: (1) The quenching distances for flames of cornstarch and aluminum in air are of the same order of magnitude as gas/air, indicating that flame theories developed for the latter may be applicable to the former. (2) Le Chatelier's Law for the lean explosive limit is not valid for coal dust-methane/air mixtures. (3) The effect of turbulence on dust-air explosions was similar to gas-air explosions.

The apparatus for measuring the thermite reaction was installed.

Fire and Explosion Hazard Research and Development

- Sulphide dusts have an explosion potential which has not, as yet, been quantified

ELLIOT LAKE LABORATORY

HIGHLIGHTS

As with other sections of MRL, the major focus at the Elliot Lake Laboratory is on developing mining technology and the protection for worker safety and the environment. These goals are attained by working closely with the mining industry.

The mining technology group's studies at Elliot Lake centre on rockburst research and mine stability. Three professionals and two technologists were added to the group during the past year.

Underground environmental studies cover the areas of dust, radiation, ventilation and noise.

Surface underground studies are concerned with mine tailings to confine their toxic components to the waste site.

In November 1985, the new Elliot Lake Laboratory was ready for occupancy and the transfer was made from the old quarters on Nordic Mine Road.

The new Elliot Lake Laboratory enhances the capability of MRL scientists to conduct studies related to the above activities. After 20 years in temporary facilities, the staff was able to advise the architects on the features in the new building that would contribute to enhanced productivity and employee satisfaction.

Private offices, each equipped with a computer terminal linked to a central facility, provide the privacy that was lacking in the previous open-concept office. The conference room is equipped with visual aids for the frequent group discussions that take place.

Enlarged laboratory spaces allow experiments to be conducted with greater efficiency. New laboratory facilities include an ultra-modern chemical laboratory, a dust tunnel for ventilation studies and the construction of a controlled environmental chamber, called the Radon-Thoron Room, which will be the central facility of a national radiation instrumentation calibration service, unique in its capability. International attention has been attracted to this facility, as indicated by the request from the Peoples' Republic of China to to have a researcher work in this facility with our scientists with the ultimate aim of duplicating this chamber in mainland China.

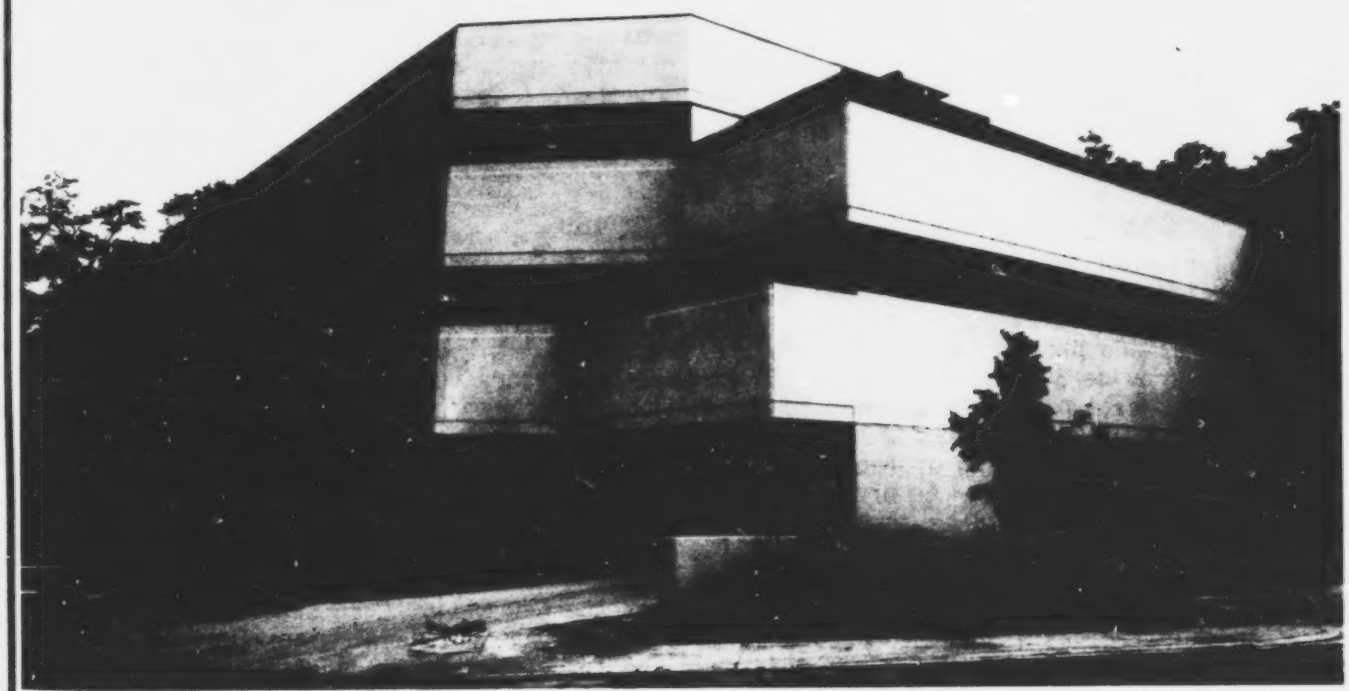
Most of the research work at the Elliot Lake Laboratory is field work, conducted at mines across Canada. Laboratory studies complement and support this work. For example, microseismic investigations at mines on the subject of rockbursts are supported by the seismograph installed at the laboratory to record events at Elliot Lake Mines. This, perhaps not surprisingly, produced a clear record of an earthquake thousands of miles away in the Northwest Territories.

The instrument shop and electronics shop build and repair mechanical and electrical instruments including microprocessors or other computer peripherals for the field teams.

Transfer of technology is an important consideration and every effort is made to complete this phase of projects.

The new laboratory is a showplace for Energy, Mines and Resources Canada, and a highly visible indication of government support to mining research across Canada.

NEW ELLIOT LAKE LABORATORY



SUB-SUB ACTIVITY: MINING TECHNOLOGY

MINE AND REGIONAL STABILITY AND ROCKBURSTS

Project Leader: D.G.F. Hedley

Objectives

1. To investigate underground stability, including rockbursts, where high stresses are the major cause of failure and to study, using instrumentation, empirical and computer models, alternative mining layouts and sequence of extraction which could alleviate these failures.

Background

High ground stresses are encountered in mines at depth and where relatively high extraction ratios concentrate the field stresses. The end result of these high stresses can be pillar or wall failures, either gradual or violent in the form of rockbursts. In the past three years 14 hard rock mines in Northern Ontario have experienced rockbursts. The rock mechanics tools available to evaluate these high stress problems are: seismic monitoring to locate rockbursts/seismic events and the relative seismic energy liberated; numerical modelling techniques to identify areas of high stress concentration and magnitudes of the energy components; and in situ measurement of stress and displacement to verify modelling predictions.

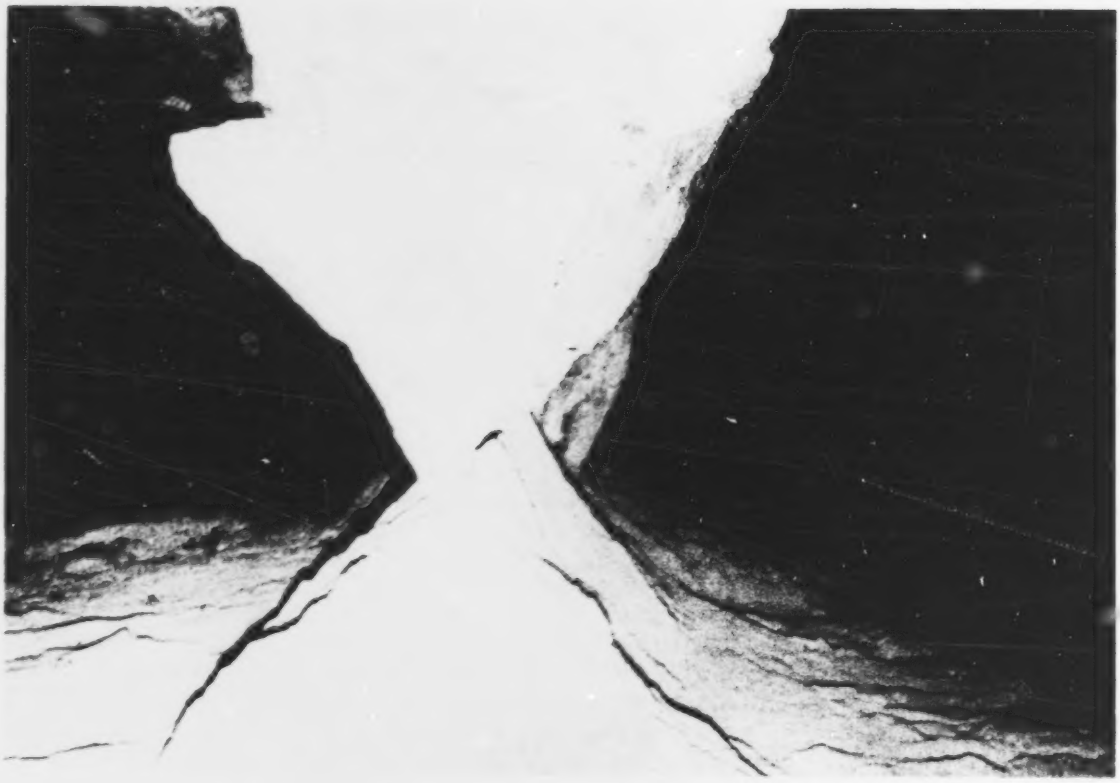
Achievements

In 1985 a major rockburst project was initiated with the Ontario mining industry and the provincial Ministry of Natural Resources. The project covers 5 years at a cost of $4.2 million with tripartite funding from the federal and provincial governments and the Ontario mining industry. CANMET will provide 5 personnel at its Elliot Lake Laboratory to operate the project. Ontario will provide equipment funds, and the industry sites and services for the installation of equipment at their mines. A Management and Technical Committee, consisting of representatives of the three parties, have been appointed to oversee the project. Work plans have been developed for rockburst research at mines in Red Lake, Elliot Lake, Sudbury and Kirkland Lake areas.

A seismograph has been installed at the new Elliot Lake Laboratory. This instrument is used to record seismic activity at the local mines (Quirke, Denison and Stanleigh) and also picks up the larger rockbursts in the Sudbury mines, as well as earthquakes world-wide.

In conjunction with the Seismology Division of EMR, a survey was made of all rockbursts that occurred in Ontario mines during 1984. In all, 106 rockbursts of magnitudes 1.5 to 4.0 were recorded in 8 Ontario mines during this period. The causes, mechanisms and locations of the larger sequence of rockbursts were documented for each mine. A collection of similar data for 1985 is under way.

Mine and Regional Stability



- Failed pillar in Nordic Mine, Elliot Lake, Ontario

The rockbursts that occurred on June 20, 1984 at the Falconbridge Mine were analyzed using a fault-slip model. Estimates of displacement, areal extent of slippage and stress drop were obtained which were in reasonable agreement with observed conditions underground.

A study was completed on the problem of multiple pillar failures in the Elliot Lake mines. Detailed surveys of pillar dimensions and strengths were collected from Denison and Quirke Mines and the probability of a "domino" type of pillar failure sequence was estimated. In conjunction with these field studies multiple testing of rock samples was done in the large laboratory press. These results indicated that it was possible to achieve non-violent pillar failures so long as the composite stiffness of all the samples was still positive. These results explain the sequence of pillar failures at Quirke Mine where the slender rib pillar failed first non-violently, followed by rockburst-type failures of the stronger sill pillars.

Laboratory tests were also conducted on rock samples surrounded by backfill. Somewhat surprisingly, cemented backfill controlled the violence of failure even when the backfill was not in contact with the platens. Also, cemented backfill controlled the post failure strength at about 50-70% of the peak strength. The large press was unavailable for six months during the move to the new laboratory. Because of this disruption further testing of this interesting phenomenon had to be postponed.

Another aspect of this project has been to measure stresses in rockburst-prone mines. This information is a prerequisite for numerical models to determine stress distributions resulting from mining activities. Measurements have been taken at Campbell Red Lake Mine on the pre-mining stresses on three levels. Also, some stress measurements were done in box-hole pillars so that they could be checked against the computer models. Also at Campbell Mine, fill pressure cells and convergence meters have been installed in cut-and-fill stopes. This is part of a long-term study on the support and energy absorbing effects of various cemented backfills in narrow steeply-dipping orebodies.

By contract, the boundary element computer program was modified so that each energy component, and hence an energy balance, was calculated after each mining step. This type of program will be used to analyze that data collected at mines experiencing rockbursts.

Significant progress was made on alternative methods of source location of seismic events. A basic "block" program was modified to accept both P and S wave arrival times and varying velocities. This method gives better locations especially when the event occurs outside the geophone array. Versions of the program have been given to the mining companies operating microseismic systems.

Rockburst Research

- D.G.F. Hedley, et al, surveying damage from a series of rockbursts at Quirke Mine, Elliot Lake (August 85) Rio Algom Mines Limited

RESPIRABLE DUST

Project Leader: J. Bigu

Objectives

1. The project element objective is to evaluate the quality and quantity of respirable dust produced in various mining operations, to identify the major factors affecting dust production, and to develop control methods capable of reducing dust concentrations to acceptable levels.

Background

Dust is a significant factor affecting both the comfort and long-term health of the work force in all mining operations. Dust from certain minerals can lead to lung disease. Lubricating oil mists and diesel exhaust also carry noxious dust and gases. In addition, in uranium mines, dust particles can carry radon and thoron daughters, and long-lived radionuclides, into the respiratory system where radiation, mostly alpha-particles, emitted internally, may give rise to tissue damage.

There is a need to improve measurement techniques (i.e., instrumentation) and programs to better assess and predict personal dust exposure, recognizing the well-established experimental fact that dust levels vary considerably for different mining operations. Furthermore, large spatio-temporal fluctuations in the dust level quite frequently occur within a given mining operation. The origin of respirable dust, its composition and size distribution, among other factors, must be known in order to determine effective control measures and to guide and interpret epidemiological and medical studies. This work requires developing an extensive database through sampling in mines using improved dust instrumentation. It also requires adequate test and calibration facilities in order to determine the accuracy of dust instrumentation.

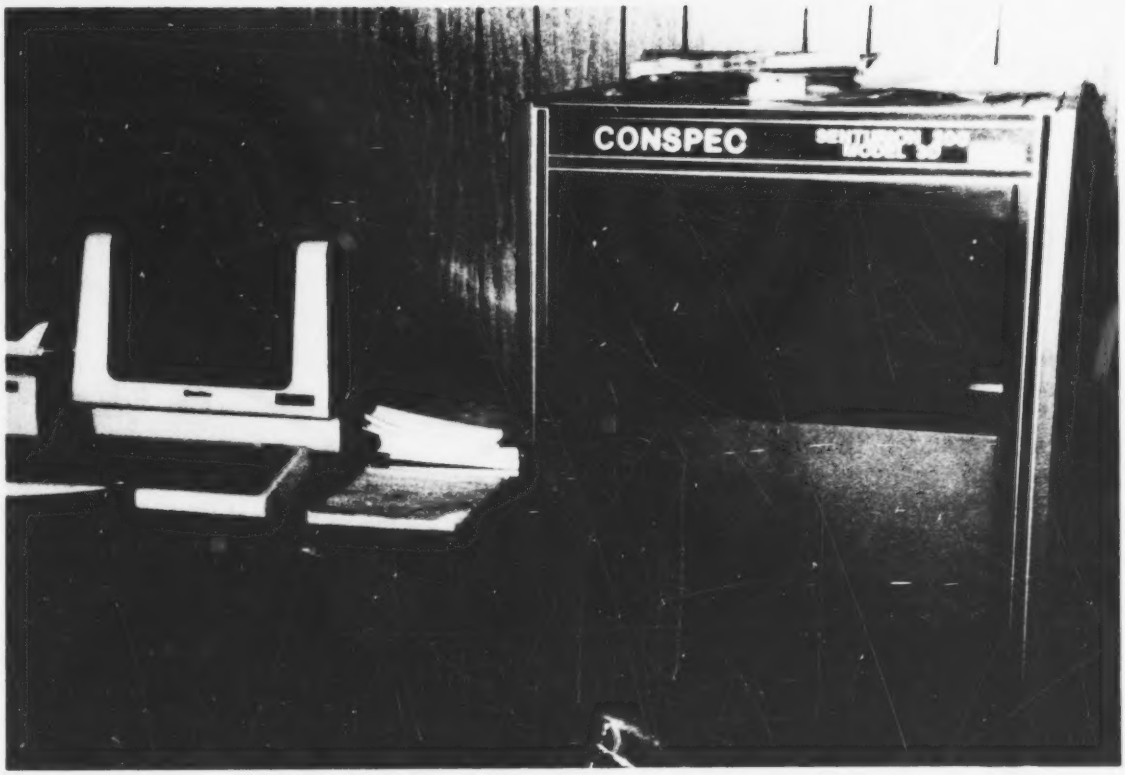
Control measure efforts centre on improving breakage and rock handling techniques to minimize dispersion of dust into the air, filtration of airborne dust, wetting techniques, as well as optimizing mine layout and ventilation. Ultimately, optimum control requires appropriate dust suppression and control methods to be built directly into mine equipment and mining methods.

Achievements

Instruments suitable for continuous monitoring of mineral, diesel and fibrous dust have been developed, but these are still in the prototype stage. Some of the instruments have been calibrated, but assessment of performance and assessment of applicability in mines is not yet complete. The monitors are designed to be compatible with the CONSPEC system for telemetering data to surface for subsequent computer processing.

The first stage in studies of dust control was to quantify the major dust sources in hard rock mines. It has been shown that blasting, crushing, and rock handling are the major dust sources. Loading rock is the main

Ventilation and Respirable Dust



- Development of modelling and automated ventilation monitoring (CONSPEC Unit)

source of dust exposure in the extractive area of the mine. Dust control studies using charged water spray systems in an underground uranium mine and mill is at present a major dust research project.

The design of a dust test facility (DTF) has been completed. The DTF has been ordered and will be installed at the Elliot Lake Laboratory during 1986.

A major, combined, dust/ventilation/radiation study in an underground uranium mine has been completed.

Suggestions for Further Work

1) Participation in combined studies with ventilation and radiation to investigate problems of practical relevance and common interest, particularly in the case of uranium mines, e.g., long-lived radioactive dust in the respirable range.

2) Development of a respirable dust/ventilation computer simulation model to better assess dust levels for personal exposure purposes.

3) Major thrust in dust control and suppression techniques including studies in rock fragmentation, wetting and rock handling and their relation to the production of dust (kind, concentration and size distribution) in mines. Also, emphasis on built-in controls is strongly recommended.

4) Maintain adequate test techniques and standards for the purpose of calibrating and testing dust instrumentation for accurate determination of dust levels.

NOISE AND VIBRATION

Project Leader: M. Savich

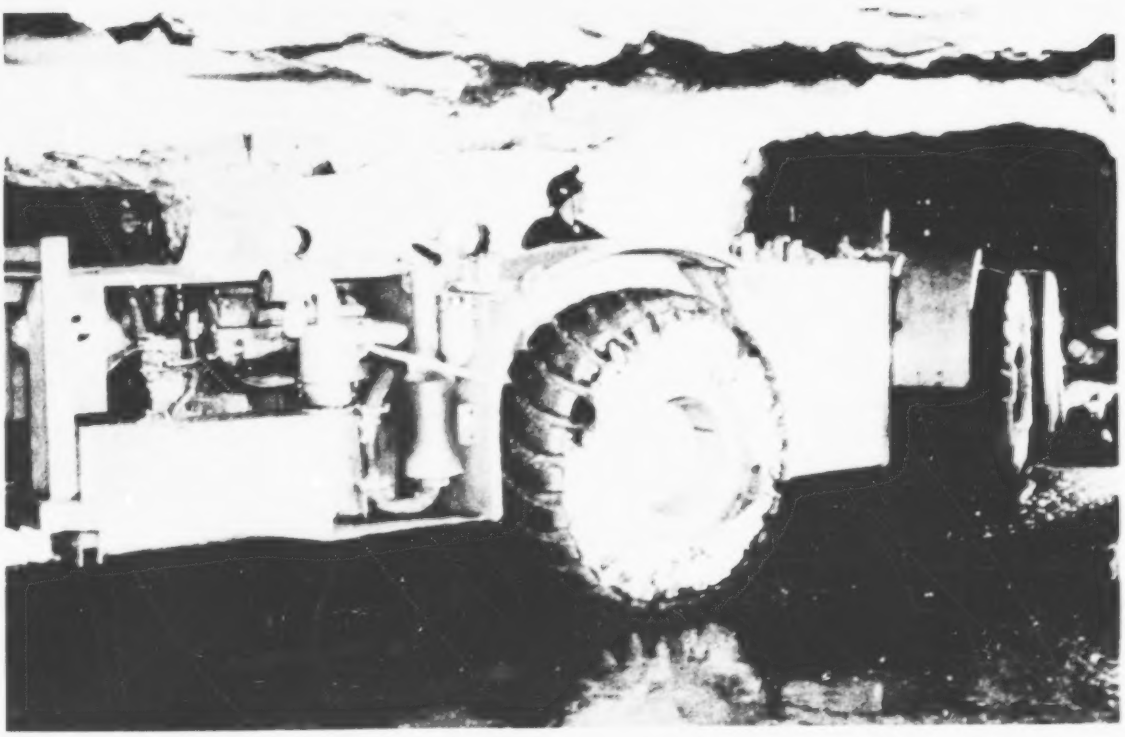
Objectives

1. To determine the magnitude and sources of environmental noise and vibration from mining operations, describe monitoring techniques and to identify applicable noise and vibration abatement techniques for maintaining the levels of these hazards within acceptable thresholds.

Background

Over ten years ago, intensive work in Canadian mines began on personal hearing protection and audiometric tests. Noise measurements have become common. The Elliot Lake Laboratory techniques and experience were transferred to Canadian mines through publications, or assistance in measurements.

Noise and Vibration



- Scooptram loading at a drawpoint (this is one of the noisiest pieces of underground equipment)

Achievements

During 1985, a lengthy field study was conducted at four Saskatchewan potash mines, to determine the noise exposure index of all workers exposed to noise on the surface and underground. Altogether 608 workers took part in the study. Noise levels around machinery were also monitored.

Data analyses and report preparation continued using the voluminous data collected during 1983/84 at four Falconbridge mines (Falconbridge, Strathcona, Fraser and Lockerby). This phase of the work was delayed because the principal scientist was on long leave during 1985.

Future Work

During Fiscal Year 1986/87 reports on Falconbridge Mine noise measurements will be completed as will reports on noise sources and noise control in mines.

RADIATION

Project Leader: J. Bigu

Objectives

1. The project element objective is to identify major sources of radiation, to identify the major factors affecting the release of radiation; to develop control methods to reduce radiation levels to acceptable personal dose exposures, and to develop and test radiation levels to acceptable personal dose exposures, and to develop and test radiation instrumentation to carry out the above studies. Another aim of the project element is the establishment of a national test facility for radon, thoron and their decay products.

Background

The radiation dose of uranium mine personnel can be minimized by limiting the time exposure, protecting the worker (e.g., shielding), and by reducing the radiation level. Mechanical (forced) ventilation is one quite effective way of reducing radiation levels at working sites. However, there are other methods that may prove to be both effective and economical in helping to control and/or minimize radiation levels. Such methods include: 1) coating mine walls with certain chemical sealants to reduce radon (thoron) migration through mine walls; 2) use of mixing fans to eliminate decay products by plate-out on the fan blades and on wall surfaces due to convective air currents set up by the fan; 3) use of DC electric fields to remove decay products by electrostatic precipitation; 4) use, in certain cases, of special 'loose' filter materials with electret properties to remove decay products by mechanical trapping and electrostatic precipitation.

Furthermore, reliable experimental radiation data depend very much on adequate performance of measuring instrumentation. Hence, reliable instrumentation and proper testing and calibration procedures of radiation instrumentation cannot be emphasized enough. In this light, the establishment

of a large test facility for radon, thoron and their decay products is of great importance. Finally, the International Commission on Radiological Protection (ICRP) has recently made recommendations regarding limits of exposure to long-lived radioactive dust in relation to total dose exposure to external gamma-radiation and airborne alpha-emitters (i.e., radon and thoron daughters in the sub-micron and respirable range). Hence, identification and quantification of long-lived radioactive dust has become an important issue.

Achievements

New instruments (monitors) suitable for continuous monitoring of radon and thoron gas, and their decay products have been developed.

The instrumentation indicated above requires calibration, assessment of performance and assessment of applicability in mines. Some of the instrumentation is intended to be compatible with the CONSPEC system for telemetering data to surface for subsequent computer processing.

Field measurements were conducted on long-lived radioactive dust (LLRD) in the sub-micron and respirable ranges. The study has been conducted at a crusher, and at a conveyor belt in underground uranium mines. The study showed significant differences in the size distribution of the LLRD from the above operations as compared with the LLRD generated in other mining operations.

Field tests of a charged water spray system were done in an underground uranium mine to investigate its effect on radiation levels including long-lived radioactive dust.

Development of radiation/ventilation mine models suitable for steady-state and time-dependent conditions continued.

A radon/thoron test facility (RTTF) for simulation studies, testing and calibration of radiation instrumentation is being installed at the Elliot Lake Laboratory. This will be the National Test Facility for radon/thoron and their decay products which is expected to begin operation on a trial basis some time in late 1986 or early 1987.

Suggestions for Further Work

Closer collaboration with respirable dust scientists to characterize long-lived radioactive dust in uranium mines as related to mining operations, in particular, rock fragmentation.

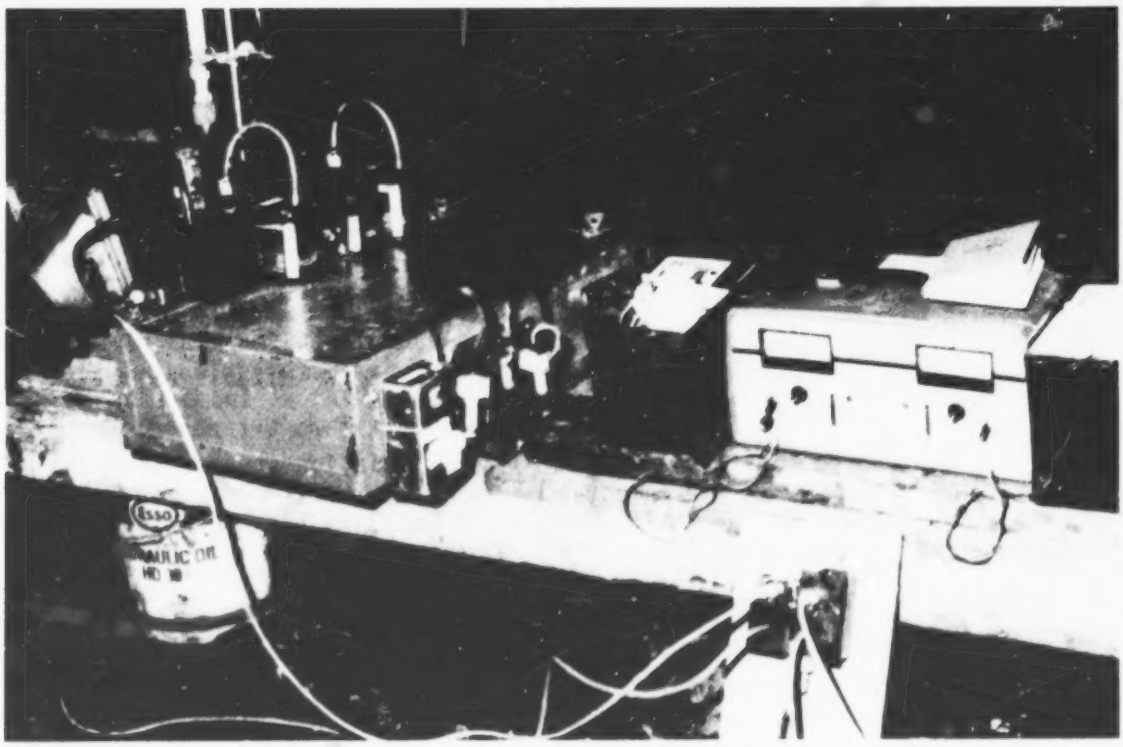
Improvement of radiation/ventilation mine models for better assessment of radon and thoron daughter radiation levels for personal exposure determinations.

Development of radiation/dust/ventilation mine models and field studies for better assessment of personal exposure levels, including exposure to long-lived radioactive dust.

A major thrust in radiation control and suppression techniques including the contribution from rock fragmentation and rock handling to the radon/thoron level and long-lived radioactive dust concentration. Major emphasis will be placed on built-in controls.

Improve tests, techniques, methods and standards for the calibration of radiation instruments.

Radiation



- Development of continuous sampling instruments which stand up to the underground environment

SUB-SUB ACTIVITY: ENVIRONMENTAL TECHNOLOGY

SOLUTION TRANSPORT AND CONTAMINANT MIGRATION FROM TAILINGS

Project Leader: N. Davé

Objectives

1. The project element objective is to develop methods of tailings treatment, disposal and surface stabilization of inactive tailings piles to reduce the detrimental effects of contaminant transport via surface run-off, groundwater infiltration as subsurface seepage and surface erosion by wind and water.

Background

The environmental problems associated with managing mine/mill waste containing metal sulphides are well recognized. Upon weathering, many metal sulphides, such as pyrite, marcasite and pyrrhotite in tailings oxidize in the presence of moisture, oxygen and iron-oxidizing bacteria - thiobacilli ferro-oxidans. The oxidation produces acidic conditions within the tailings, which subsequently leaches many residual metals (and trace radionuclides in uranium tailings) from the tailings material resulting in highly acidic, high total dissolved solids, tailings porewater. With precipitation and recharge events, these oxidation reaction products can migrate from the tailings with surface run-off, and as subsurface seepage to the surrounding environment, thereby affecting the natural quality of the area water system if control methods were not used. To control wind and water erosion, many inactive tailings sites have been successfully stabilized by revegetation which has greatly improved the aethetics, and to a certain extent, the amount of water percolating through, because of increased evapotranspiration. The overall impact of revegetation on quality and quantity of effluent from reclaimed tailings area has yet to be determined. CANMET's research objectives are to develop an effective technology of tailings disposal and management to minimize environmental impact.

Achievements

Under the Reactive Tailing (RATS) program, hydrogeochemical investigations of highly reactive sulphide tailings are being carried out at the Waite Amulet tailings site in Noranda, Quebec. Preliminary geophysical investigations including seismic, electromagnetic and electrical resistivity surveys have been completed. The results showed an irregular bedrock topography with a clay layer of varying thickness underneath the tailings. Within the tailings, a hardpan layer of tailings exists above the watertable which roughly marks the boundary between oxidized and unoxidized zones. Continuous solid core tailings samples were obtained at nine locations for physical, mineralogical and chemical analyses. At two more locations, tailings were sampled for bacterial counts, including iron oxidizing and sulphate reducing organisms. A total of 55 piezometers have been installed in and around the tailings to monitor groundwater flow paths, tailings porewater chemistry and

migration of contaminants. The pH and electrical conductance of the tailings pore water varied between 5 to 7.5 and 1000 to 10 000 μs respectively. Fe, Ca, Mg, Zn and SO_4^{-2} have been the major ionic constituents of tailings porewater. Results to date have indicated that because of the reduced permeability of the clay layer a good aquitard has developed with the result that the tailings porewater drains through the impoundment dams. Oxidation of the near neutral tailings porewater also takes place as it passes through shallow zones near the dams. This study is being conducted in collaboration with the Noranda Research Centre, Pointe Claire, Quebec and Noranda Mines Ltd.

Under two separate contracts, work is also being carried out at INCO and Falconbridge tailings sites at Sudbury, Ontario dealing with various methods of reducing acid generation and subsequent leaching of sulphide tailings. These methods include establishment of wetlands as tailings, chemical treatment, such as the use of sodium lauryl sulphate, and biological covers, such as sewage sludges.

At the Nordic tailings site in Elliot Lake, Ontario, work on the tailings area water budget is underway in collaboration with the Water Survey of Canada, Guelph, Ontario. Total inflow, outflow and precipitation at the Nordic main tailings site are being monitored.

APPENDIX A

PUBLICATIONS

SPECIAL PUBLICATIONS

SP 85-05	Rockbursts in Ontario Mines during 1984.	D. Hedley R. Wetmiller
SP 85-12	Index of Mining technology development 1985	R. Welwood

DIVISION REPORTS

ACEA = Administration of the Canada Explosives Act

M&ET = Mineral and Energy Technology

MRL = Mining Research Laboratories

JOURNAL SUBMISSIONS (J)

M&ET/MRL 85-28(J)	RA-226 concentrations in blueberries (vaccinium angustifolium Ait.) near an inactive uranium tailings site in Elliot Lake, Ontario. [Revision of Division Report MRP/MRL 84-95(J)]	N. Davé T.P. Lim N. Cloutier
M&ET/MRL 85-88(J)	Theory and application of radon and thoron progeny monitoring under steady-state and non-steady state radiation conditions - Part I: Active sampling	J. Bigu
M&ET/MRL 85-91(J)	Theory and application of radon and thoron progeny monitoring under steady-state and non steady-state radiation conditions - Part II: Passive sampling	J. Bigu
M&ET/MRL 85-105(J)	Comparison of dust samplers: Statistical analysis techniques	G. Knight E. Moore
M&ET/MRL 85-115(J)	A microprocessor-based continuous monitor with alpha-spectroscopy capabilities for the determination of radon, thoron and their progeny	J. Bigu R. Kaldenbach
M&ET/MRL 85-116(J)	Electrical characteristics of the short-lived decay products of thoron in underground uranium mines	J. Bigu M. Grenier
M&ET/MRL 85-117(J)	Plate-out of radon and thoron progeny on different materials	J. Bigu
M&ET/MRL 85-120(J)	A method for determining thoron and radon gas concentrations using solid-state alpha-particle detectors	J. Bigu

M&ET/MRL 85-122(J)	Gravimetric sampling: Practical problems [Revision of Division Report MRP/MRL 84-92(J)]	G. Knight
M&ET/MRL 85-123(J)	An automated multisensor apparatus for comparative membrane radon and thoron permeability studies	J. Bigu
M&ET/MRL 85-130(J)	Attachment of radon and thoron progeny to the surface of different materials	J. Bigu
M&ET/MRL 85-131(J)	Microprocessor controlled down-the-hole drill	J. Pathak S. Baginski

ORAL PRESENTATIONS (OP)

M&ET/MRL 85-8(OP)	The Canadian Explosive Atmospheres Laboratory	J. Bossert
M&ET/MRL 85-17(OP)	Towards determining the extent of mining research in Canada	J. Udd R. Welwood
M&ET/MRL 85-23(OP)	Microseismic monitoring in Canadian mines	Compiled by J. Udd
M&ET/MRL 85-31(OP)	Rockbursts at Campbell Red Lake Mine	D. Hedley M. Neumann T. Makuch W. Blake
M&ET/MRL 85-48(OP)	The usage of weighted averages in grade estimation of stratiform ore deposits	Á. Füstös
M&ET/MRL 85-55(OP)	Development of the AQI/EQI concept - A ventilation performance standard for dieselized underground mines	P. Mogan D. Dainty
M&ET/MRL 85-58(OP)	Strength of a large mine pillar	G. Herget
M&ET/MRL 85-65(OP)	Robotics in mining - A Canadian view	J. Pathak
M&ET/MRL 85-69(OP)	Summary reports of progress on tri-partite USBM/MOL/CANMET Research projects	J. Udd D. Dainty L. Geller
M&ET/MRL 85-90(OP)	Progress during the first half of 1985 in the environment projects of the CANMET Minerals Program	J. Bigu
M&ET/MRL 85-97(OP)	Prospective de la Recherche Minière Canadienne et le Rôle de CANMET	J. Udd N. Billette

ORAL PRESENTATIONS AND JOURNAL SUBMISSIONS (OPJ)

M&ET/MRL 85-4(OPJ)	Investigation of the CTO emission control system applied to heavy-duty diesel engines used in underground mining equipment	P. Mogan H.C. Vergeer K.C. Westaway J.K. Weglo A. Lawson D. Dainty L.R. Thomas
M&ET/MRL 85-6(OPJ)	Conveyor belting flammability testing in Canada	K. Mintz
M&ET/MRL 85-20(OPJ)	A comparison of some approaches to the classification of rock masses for geotechnical purposes	J. Udd H. Wang
M&ET/MRL 85-38(OPJ)	Characterization of ceramic diesel exhaust filter auto-regeneration in a hardrock mine	D. Dainty C. Bourré W. Elliott
ACEA/MRL 85-44(OPJ)	Calculation of detonation products by means of the CS hard-sphere equation of state	K. Feng W. Chung B.C.-Y. Lu
M&ET/MRL 85-49(OPJ)	A rationale for size selective dust sampling definitions and design	G. Knight
M&ET/MRL 85-56(OPJ)	Evaluation of diesel emissions control technology at Cominco's Sullivan Mine	M. Gangal D. Dainty L. Weitzel M. Bapty
TM&E/LRM 85-56(OPJ)	Evaluation des techniques de réduction des émissions de diesel dans la mine Sullivan de Cominco	M. Gangal D. Dainty L. Weitzel M. Bapty
M&ET/MRL 85-57(OPJ)	Sand replacement of tailings backfill: Some design guidelines	G. Swan
M&ET/MRL 85-70(OPJ)	Analysis of friction factors in mine ventilation systems	M. Gangal K. Notley J. Archibald
M&ET/MRL 85-71(OPJ)	Thoron determination using activated carbon and a high purity germanium detector	J. Bigu
M&ET/MRL 85-76(OPJ)	Generation and control of mine airborne dust	G. Knight
M&ET/MRL 85-80(OPJ)	Migration of metals and trace radionuclides from mine tailings to the environment	N. Davé T.P. Lim N. Cloutier

M&ET/MRL 85-81(OPJ)	Characterization of radioactive dust in Canadian underground uranium mines	J. Bigu M. Grenier
M&ET/MRL 85-82(OPJ)	Computer predicted airborne respirable dust concentrations in mine air recirculation systems	S. Hardcastle
M&ET/MRL 85-85(OPJ)	Methods of roughness analysis for predicting rock joint behaviour	G. Swan
M&ET/MRL 85-92(OPJ)	The effect of time-dependent ventilation rates in partially enclosed radioactive environments	J. Bigu
M&ET/MRL 85-114(OPJ)	Fault-slip rockbursts at the Falconbridge Mine	D. Hedley S. Bharti D. West W. Blake
M&ET/MRL 85-125(OPJ)	International cooperation in research applied to automated mining and tunneling - A Canadian position and proposed action plan	J. Udd
M&ET/MRL 85-126(OPJ)	An overview of current major research and trends in Canadian mining technology	J. Pathak
ACEA/MRL 85-141(OPJ)	Evaluation of the propagation sensitivity of small diameter blasting slurries, water gels and emulsions	K. Feng R. Vandebeek A.W. Bauer A. Bauer
M&ET/MRL 85-144(OPJ)	Haulage system capacity: Analytical and simulation models revisited	N. Billette B. Seka

TECHNICAL REPORTS (TR)

M&ET/MRL 85-1(TR)	Seminar on Canadian potash mining and ground control	G. Herget J. Pathak M. Gyenge L. Geller G. Knight Y. Yu M. Bétournay
M&ET/MRL 85-3(TR)	Preview of CANMET's mining technology development index	R. Welwood
M&ET/MRL 85-3(TR)	Exposé préliminaires de l'index de CANMET sur le développement des technologies minières	R. Welwood
M&ET/MRL 85-11(TR)	Effect of relative humidity on antistatic properties of non-metallic mine materials	N. Sarin

M&ET/MRL 85-13(TR)	Potash mine dust experiments - 1984	G. Knight
M&ET/MRL 85-14(TR)	Preliminary results of rock joint testing on URL core	R. Jackson A. Annor A.S. Wong M. Bétournay
ACEA/MRL 85-16(TR)	Thermal stability evaluation of samples from ammonium nitrate melt line explosion by accelerating rate calorimetry	P. Lee R. Vandebeek
M&ET/MRL 85-19(TR)	Rock mechanics research in the Mining Research Laboratories of CANMET, 1964-1984 - A submission to the provincial inquiry into ground control and emergency preparedness in Ontario mines	J. Udd D. Hedley
M&ET/MRL 85-21(TR)	The use of rapid reading airborne dust instruments in mines and mills	G. Knight
M&ET/MRL 85-24(TR)	Index of rock mechanics research reports CANMET/MRL, 1964-1984	D. Hedley J. Udd
M&ET/MRL 85-25(TR)	Evaluation of a semi-micro analytical balance to perform on-filter determina- of dust mass	S. Hardcastle
M&ET/MRL 85-26(TR)	Comparison of prototype diesel/mineral monitors against a Simslin II	S. Hardcastle
M&ET/MRL 85-29(TR)	Deposition of dust in mine galleries	G. Knight S. Hardcastle
M&ET/MRL 85-32(TR)	MSHGEN documentation (Vax-11/750 version) - A mesh generating program for finite element analysis of two dimensional structures	N. Toews Y. Yu A.S. Wong
M&ET/MRL 85-33(TR)	MSHPLT documentation (Vax-11/750 version) - A mesh plotting program for finite element analysis	N. Toews Y. Yu A.S. Wong
M&ET/MRL 85-34(TR)	SAP2DC documentation (Vax-11/750 version) - An interface program for the finite element program SAP2D	Y. Yu N. Toews A.S. Wong
M&ET/MRL 85-35(TR)	SAP2D documentation (Vax-11/750 version) - 2D linear elastic finite element program	N. Toews Y. Yu A.S. Wong
M&ET/MRL 85-36(TR)	Assessment of recoverable coal reserves Estevan Coalfield, Saskatchewan	Á. Füstös A. Boyer R. Boyle

M&ET/MRL 85-37(TR)	Assessment of recoverable coal reserves Willow Bunch Coalfield, Saskatchewan	D. Walsh R. Boyle
M&ET/MRL 85-39(TR)	Progress review for 1984/85 on mine safety and productivity projects under the Canada/Manitoba Minerals Development Agreement	Y. Yu S. Vongpaisal
M&ET/MRL 85-40(TR)	Flammability of a polyethylene idler roll	K. Mintz
M&ET/MRL 85-41(TR)	Mechanical properties of rock samples from the Lac du Bonnet batholith, Manitoba	A. Annor R. Jackson
M&ET/MRL 85-47(TR)	Performance test of Spectraspan V sequential atomic emission spectrometer	T.P. Lim N. Cloutier Y. Boucher N. Davé
M&ET/MRL 85-51(TR)	Theory of diffusion of radon and thoron through membranes under steady-state and time-dependent radiation conditions - Part II (time-dependent case)	J. Bigu
M&ET/MRL 85-52(TR)	Theory of diffusion of radon and thoron through membranes under steady-state and time-dependent conditions - Part I (steady-state case)	J. Bigu
M&ET/MRL 85-53(TR)	Theoretical considerations regarding the behaviour of a mine model with ventilation under time-dependent radiation conditions	J. Bigu
M&ET/MRL 85-54(TR)	Theoretical considerations regarding the growth and decay of the short-lived decay products of radon and thoron plated-out on large surfaces	J. Bigu
M&ET/MRL 85-59(TR)	Certification and testing services for equipment and materials for use in gaseous mines, non-gaseous mines, and other hazardous locations	Canadian Explosive Atmospheres Laboratory
M&ET/MRL 85-60(TR)	CSA Standard M424 - Iteration # 7 Flameproof diesel-powered vehicles for use in gassy underground coal mines	Compiled from Technical Committee Consultation by D. Dainty and G. Lobay
M&ET/MRL 85-61(TR)	List of certified equipment and materials for use in underground mines	J. Bossert M. Ralph G. Lobay N. Sarin M. Inglis

M&ET/MRL 85-63(TR)	Field stress determinations at Macassa Mine, Kirkland Lake, Ontario	B. Arjang G. Vaillancourt
M&ET/MRL 85-64(TR)	Program alphaprint for the processing of data acquired by an Alphanuclear Ltd. logger system	M. Grenier
M&ET/MRL 85-66(TR)	Mining Research Laboratories Annual Report 1984-1985	Compiled by C. Sabourin
ACEA/MRL 85-68(TR)	Apparatus for measuring the velocity of projectiles	E. Nagy E. Contestabile
M&ET/MRL 85-72(TR)	Radon progeny and thoron progeny plate-out on a variety of materials	J. Bigu A. Frattini
M&ET/MRL 85-75(TR)	Theoretical considerations regarding active sampling of time-dependent radon (thoron) atmospheres	J. Bigu
M&ET/MRL 85-77(TR)	Stress determination at Detour Lake Mine, Northern Ontario	B. Arjang G. Herget
M&ET/MRL 85-78(TR)	Notes on Denison Mine pillar-backfill confinement tests	G. Swan
M&ET/MRL 85-83(TR)	On filter self-absorption and loading characteristics	M. Grenier
ACEA/MRL 85-84(TR)	CERL's modified type 12 impact tool	E. Contestabile T. Pike T. Craig
M&ET/MRL 85-86(TR)	SAPPLT documentation (VAX-11/750 version) An interface program for the general purpose plotting program MRLPLT	Y. Yu N. Toews A.S. Wong S. Vongpaisal
M&ET/MRL 85-93(TR)	Monitoring of stability conditions at Falconbridge's Strathcona Mine	J. Udd S. Bharti
M&ET/MRL 85-95(TR)	SAP2D System - An overview	Y. Yu N. Toews
M&ET/MRL 85-101(TR)	Stress tensor determinations with the South African biaxial strain cell (doorstopper)	G. Herget
ACEA/MRL 85-102(TR)	CERL's fume testing facility for explosives Part I: Design and evaluation of explosion containment vessel	E. Contestabile D. Cox T. Craig D. Hamel

M&ET/MRL 85-103(TR)	Multiple pillar compression failure in brittle rock	G. Swan
ACEA/MRL 85-104(TR)	Constant current supply for the determination of detonation velocities and reference voltage source	E. Nagy
M&ET/MRL 85-106(TR)	The CANMET/MRL Rockburst Research Project - An updated work plan	D. Hedley J. Udd
M&ET/MRL 85-107(TR)	Bibliography of non-confidential ORAG reports from 1975 to August 1985	A. Boyer
M&ET/MRL 85-112(TR)	Methods for evaluating weak ground, Les Mines Selbaie, Québec	G. Swan
M&ET/MRL 85-118(TR)	The effects of water content on the uniaxial mechanical properties of WN1 core samples	R. Jackson A. Annor
ACEA/MRL 85-119(TR)	Large sample drop weight test evaluation	E. Contestabile D. Hamel D. Cox T. Craig
M&ET/MRL 85-127(TR)	Strength distributions and potential for multiple pillar collapse	G. Swan
M&ET/MRL 85-129(TR)	The preconditioning test for fire-resistant hydraulic fluids	N. Sarin K. Mintz
M&ET/MRL 85-133(TR)	Assessment of recoverable coal reserves Wood Mountain Coalfield, Saskatchewan	A. Boyer D. Walsh R. Boyle
M&ET/MRL 85-135(TR)	A progress report - Study of coarse slurry, short-distance pipelining	L. Geller
M&ET/MRL 85-138(TR)	MRL confined shear test method	M. Gyenge
M&ET/MRL 85-139(TR)	A proposal for a research project on open pit transportation maintenance	N. Billette
ACEA/MRL 85-143(TR)	Fundamental information for Tiger Code calculations on explosives (1)	D. Jones K. Feng
M&ET/MRL 85-145(TR)	Source register for CANMET Mining Technology Development Index	R. Welwood
M&ET/MRL 85-146(TR)	Maritime and British Columbia field trip reports for CANMET Mining Technology Development Index	R. Welwood

INTERNAL REPORTS (INT)

M&ET/MRL 85-2(INT)	Additional laboratory test results of rock cores from strata control hole #6, Donkin-Morien rock support interaction contract	B. Gorski
M&ET/MRL 85-5(INT)	Sixth International Congress on Rock Mechanics (Aug. 30-Sept. 3, 1987, Montreal, Que.) - A progress report to December 1984	L. Geller G. Herget
M&ET/MRL 85-7(INT)	Airborne dust control for hardrock mines: Position paper and an outline for research and development 1985-1992	G. Knight
M&ET/MRL 85-9(INT)	Laboratory test results of rock cores from borehole 3T804, Donkin-Morien rock support interaction contract	B. Gorski
M&ET/MRL 85-10(INT)	Ore handling practices and trends	R. Clarke
M&ET/MRL 85-12(INT)	Documentation of DRUKPRA	N. Toews Y. Yu A.S. Wong S. Vongpaisal
M&ET/MRL 85-15(INT)	Documentation of DRUKSTA (VAX/VMS version)	N. Toews Y. Yu S. Vongpaisal A.S. Wong
M&ET/MRL 85-18(INT)	VAX memo creation utility	N. Toews A.S. Wong Y. Yu
M&ET/MRL 85-22(INT)	A preliminary assessment of the BMINES computer code	S. Vongpaisal A.S. Wong N. Toews Y. Yu
M&ET/MRL 85-43(INT)	Sixth International Congress on Rock Mechanics (Aug. 30-Sept. 3, 1987, Montreal) - A progress report to Feb. 25, 1985	L. Geller G. Herget
M&ET/MRL 85-45(INT)	Strength determination of Detour Lake Mine rocks	B. Gorski
M&ET/MRL 85-50(INT)	Annual Review - Elliot Lake Laboratory	R. Tervo
M&ET/MRL 85-62(INT)	Confined shear test method to establish the frictional and strength properties of jointed rocks	M. Gyenge

M&ET/MRL 85-67(INT)	Summary reports of progress on 1984/85 mineral projects, Mining Research Laboratories	Prepared by: J. Udd D. Dainty G. Larocque J. Pathak C. Sabourin
M&ET/MRL 85-73(INT)	Sixth International Congress on Rock Mechanics (Aug. 30-Sept. 3, 1987, Montreal) - A progress report to May 29, 1985	L. Geller G. Herget
M&ET/MRL 85-96(INT)	Sixth International Congress on Rock Mechanics (Aug. 30-Sept. 3, 1987, Montreal) - A progress report to July 2, 1985	L. Geller G. Herget
ACEA/MRL 85-100(INT)	Tiger Code User's Guide	G. Vert
M&ET/MRL 85-108(INT)	Additional strength determinations of Detour Lake Mine rocks	B. Gorski
M&ET/MRL 85-109(INT)	Mine cost model structure and analysis of cut off grade sensitivity to accuracy of costs estimated for a mine cost model	R. Clarke
M&ET/MRL 85-110(INT)	ISRM Advisory and Council Meeting at Zacatecas, Mexico	G. Herget J. Udd
M&ET/MRL 85-111(INT)	Comparison of Elliot Lake Laboratory air flow meters	G. Knight
M&ET/MRL 85-113(INT)	VAX Datatrieve User's Guide for MRL Expenditure Database	A.S. Wong
ACEA/MRL 85-121(INT)	Operating instructions for the HP9816S/ DL2808 system multichannel recorder	A.S. Danis
M&ET/MRL 85-124(INT)	Strength determinations of Central Canada potash rocks	B. Gorski
M&ET/MRL 85-128(INT)	Strength determinations of Prince Mine rocks	B. Gorski
M&ET/MRL 85-132(INT)	Research proposal-fragmentation project	R. Clarke
M&ET/MRL 85-134(INT)	Preliminary results of high temperature and high pressure triaxial testing on Ontario Hydro specimens	R. Jackson

INVESTIGATION REPORT (IR)

M&ET/MRL 85-79(IR)	Minutes of the 2nd Rock Mechanics and Strata Control Committee Business Meeting held in Vancouver, April 22, 1985	G. Swan

PRESENTATIONS

Bigu, J. "A Method for determining thoron gas concentrations"; presented at Conference on Environmental Radiation '85, Colorado Springs, CO, Jan. 6-10, 1985.

Bigu, J. "Thoron determination using activated carbon and a high purity germanium detector"; presented at OECD/NEA Workshop, Paris, France, May 20-22, 1985.

Bigu, J. and Grenier, M. "Characterization of radioactive dust in Canadian underground uranium mines"; presented at the 2nd U.S. Mine Ventilation Congress, Reno, NV, Sept. 25-26, 1985.

Bigu, J. "Progress during the first half of 1985 in the environment projects of the CANMET Minerals Program"; presented at the Joint Panel on Occupational and Environmental Research for Uranium Production in Canada, Chalk River, Ontario, June 25-26, 1985.

Bigu, J. "The effect of time-dependent ventilation rate in partially enclosed radioactive environments"; presented at the Ventilation Congress, Toronto, Ontario, Oct. 1-3, 1985.

Bigu, J. "Progress during the second half of 1985 in the environment projects of the CANMET Minerals Program"; presented at the Joint Panel on Occupational and Environmental Research for Uranium Production in Canada, Toronto, Ontario, December 1985.

Billette, N.R. "Haulage system capacity: Analytical and simulation models revisited" presented at APCOM '86, the 19th International Symposium on the Application of Computers and operations research in the mineral industry, April 14-18, 1986.

Bossert, J.A. "The Canadian Explosive Atmopheres Laboratory"; presented at the 1985 Mechancial/Electrical Symposium, Victoria, B.C., Feb. 19-22, 1985.

Dainty, E.D., Bourre, C. and Elliott, W.T. "Characterization of ceramic diesel exhaust filter auto-regeneration in a hard rock mine"; presented to the Annual General Meeting of the Mines Accident Prevention Association of Ontario, Toronto, Ontario, May 1985.

Dainty, E.D., Mogan, J.P., Lawson, A. and Mitchell, E.W. "The status of total exhaust filter development for underground mines"; presented to the 21st Intnl Conference of Safety in Mines Research Institutes, Sydney, Australia, Oct. 21-25, 1985.

Davé, N., Cloutier, N. and Lim, T.P. "Radionuclide levels in vegetation growing on uranium tailings Elliot Lake, Ontario"; presented at the 7th Annual Symposium on Management of Uranium Mill Tailings, Low-level Waste and Hazardous Waste, Fort Collins, CO, Feb. 4-5, 1985.

Feng, K.K., Chung, W.K. and Lu, B.C.-Y. "Calculation of detonation product by means of the CS hard-sphere equation of state"; presented at the 8th Symposium (International) on Detonation, Albequerque, NM, July 15-19, 1985.

Gangal, M.K., Dainty, E.D., Weitzel, L. and Bapty, M. "Evaluation des techniques de réduction des émissions de diésel dans la mine Sullivan de COMINCO"; présenté au Symposium de Mécanique Électrique, Victoria, Colombie Britannique, Fév. 19-22, 1985.

Gangal, M.K., Dainty, E.D., Weitzel, L. and Bapty, M. "Evaluation of diesel emissions control technology at COMINCO's Sullivan mine"; presented at the 4th Mechanical Electrical Engineering Symposium, Victoria, B.C., Feb. 19-22, 1985.

Gangal, M.K., Notely, K.R. and Archibald, J.F. "Analysis of friction factors in mine ventilation systems"; presented at the 2nd U.S. Mine Ventilation Symposium, Reno, NV, Sept. 23-25, 1985.

Hardcastle, S. "Computer predicted airborne respirable dust concentrations in mine air recirculation systems"; presented at the 2nd U.S. Mine Ventilation Symposium, Reno, NV, Sept. 25-26, 1985.

Hedley, D., Neumann, M., Makuch, T. and Blake, W. "Rockbursts at Campbell Red Lake Mine"; presented at Rockburst Seminar, Sudbury, Ontario, March 26-27, 1985.

Hedley, D., Bharti, S., West, D. and Blake, "Fault-slip rockbursts at the Falconbridge Mine"; presented at the 4th Conference on Acoustic Emission/ Microseismic Activity in Geologic Structures and Materials, Pennsylvania State University, Oct. 22-24, 1985.

Herget, G. "Strength of a large mine pillar"; presented at the Intnl Symposium on the Role of Rock Mechanics in Excavations to Mining and Works, Zacatecas, MX, Sept. 3, 1985.

Knight, G. "A rationale for size selective dust sampling - definitions and design"; presented at the 1985 Am Ind Hyg Conference.

Knight, G. "Generation and control of mine airborne dust"; presented at the 2nd U.S. Mine Ventilation Symposium, Reno, NV, Sept. 25-26, 1985.

Lawson, A., Vergeer, H.C., Drummond, W., Mogan, J.P. and Dainty, E.D. "Performance of a ceramic diesel particulate trap over typical mining duty cycles using fuel additives"; presented to the Intnl Congress of the Society of Automotive Engineers, Detroit, MI, February 1985.

Mintz, K.J. "Conveyor belting flammability testing in Canada"; presented to the 21st Intnl Conference of Safety in Mines Research Institutes, Sydney, Australia, Oct. 21-25, 1985.

Mogan, J.P., Vergeer, H.C., Westaway, K.C., Weglo, J.K., Lawson, A., Dainty, E.D. and Thomas, L.R. "Investigation of the CTO emission control system applied to heavy-duty diesel engines used in underground mining equipment"; presented to the Intnl Congress of the Society of Automotive Engineers, Detroit, MI, February 1985.

Mogan, J.P. and Dainty, E.D. "Development of the AQI concept - a ventilation performance standard for dieselized underground mines"; presented to the Intnl Conference on the Health of Miners, Pittsburgh, PA, June 1985.

Pathak, J. "Robotics in mining - a Canadian view"; presented at the Robotics in Mining Workshop, Paris, France, May 21-22, 1985.

Pathak, J. "An overview of current major research and trends in Canadian Mining Technology"; presented at the 1st Intnl Symposium on Innovative Mining Systems at the Massachusetts Institute of Technology, Cambridge, MA, Nov. 4-5, 1985.

Swan, G. "Sand replacement of tailings backfill: Some design guidelines"; presented at the CIM, A.G.M., Vancouver, B.C., April 22-25, 1985.

Swan, G. "Methods of roughness analysis for predicting rock joint behaviour"; presented at the Intnl Symp on Fundamentals of Rock Joints, Bjorkliden, Sweden, Sept. 15-20, 1985.

Udd, J.E. and Wang, H. "A comparison of some approaches to the classification of rock masses for geotechnical purposes"; presented at the 26th U.S. Symposium on Rock Mechanics, Rapid City, SD, June 26-28, 1985.

Udd, J.E. and Welwood, R.J. "Towards determining the extent of mining research in Canada"; presented at the Annual General Meeting of the Canadian Institute of Mining and Metallurgy, Vancouver, B.C., April 1985.

Udd, J.E. and Hedley, D. "Rock mechanics in the Mining Research Laboratories of CANMET, 1964-1984"; presented to the Provincial Inquiry into Ground Control and Emergency Preparedness in Ontario Mines, Sudbury, Ontario, March 25, 1985.

Udd, J.E. "Microseismic monitoring in Canadian mines"; presented to a CANMET sponsored workshop held in Sudbury, Ontario, Aug. 14-15, 1984.

Udd, J.E., Dainty, E.D. and Geller, L. "Summary reports of progress on tripartite USBM/MOL/CANMET Research projects"; presented at the Annual USBM-CANMET Meeting, Pittsburgh, PA, May 29-30, 1985.

Udd, J.E. et Billette, N.R. "Prospective de la recherche minière Canadienne et le rôle de CANMET"; présenté au colloque sur l'impact des nouvelles technologies sur les entreprises minières de l'Abitibi-Témiscamingue Rouyn, Québec, 30 septembre 1985.

Udd, J.E. "International cooperation in research applied to automated mining and tunnelling - A Canadian position and proposed action plan"; presented at a meeting on Intnl Cooperation in Research Applied to Automated Mining and Tunneling, Cambridge, MA, Nov. 6, 1985.

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Bigu, J. "Removal of airborne thoron (radon) daughters on mine walls and other surfaces by convective deposition and electrostatic plate-out"; Proc of the Intnl Conf on Occupational Radiation Safety in Mining, 1984.

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Billette, N.R. "Automates et robots en exploitation minière: Evolution prévisible à court terme" Colloque sur la Recherche Minérale, son impact sur la rentabilité, page 280, Québec City, Québec, 18 et 19 fevrier 1986.

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Dainty, E.D., Bourre, C. and Elliott, W.T. "Characterization of ceramic diesel exhaust filter auto-regeneration in a hard rock mine"; Published by MAPAO by reprinting the CANMET version and distributing it at the conference in a coloured MAPAO Conference cover.

Dainty, E.D., Mogan, J.P., Lawson, A. and Mitchell, E.W. "The status of total exhaust filter development for underground mines"; Proc of the 21st Intnl Conference of Safety in Mines Research Institutes, 453-460; Oct. 21-25, 1985.

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Feng, K.K., Chung, W.K. and Lu, B.C.-Y. "Calculation of detonation product by means of the CS hard-sphere equation of state"; Proc of the 8th Symp (Intnl) on Detonation, 139-147; Albequerque, NM, July 1985.

Gangal, M.K., Dainty, E.D., Weitzel, L. and Bapty, M. "Evaluation of diesel emissions control technology at COMINCO's Sullivan mine"; Proc Mechanical Electrical Symp, 2:27; Victoria, B.C., Feb. 19-23, 1985.

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Hardcastle, S. "Computer predicted airborne respirable dust concentrations in mine air recirculation systems"; Proc 2nd U.S. Mine Ventilation Cong, 239-248; Reno, NV, September, 1985.

Hedley, D., Roxburgh, J. and Muppalaneni, S. "A case history of rockbursts at Elliot Lake"; Proc of Intnl Conf on Stability in Underground Mining, p. 210; Lexington, KY, 1984.

Knight, G. "Generation and control of mine airborne dust"; Proc 2nd U.S. Mine Ventilation Cong, 139-151; Reno, NV, Sept. 1985.

Mintz, K.J. "Conveyor belting flammability testing in Canada"; Proc 21st Intnl Conf of Safety in Mines Research Institutes, 545-552;

Pathak, J. "Robotics in mining - a Canadian view"; Proc Robotics in Mining Workshop, 11 pages; Paris, France, May 21-22, 1985.

Pathak, J. "An overview of current major research and trends in Canadian mining technology"; Proc 1st Intnl Symp on Innovative Mining Systems, 27 pages; Massachusetts Institute of Technology, Cambridge, MA, Nov. 4-5, 1985.

Swan, G. "Methods of roughness analysis for predicting rock joint behaviour"; Proc Intnl Symp Fundamentals of Rock Joints, Bjorkliden, Sweden, Sept. 1985.

Udd, J.E. and Wang, H. "A comparison of some approaches to the classification of rock masses for geotechnical purposes"; Proc 26th U.S. Symp on Rock Mechanics, pages 69-78; South Dakota School of Mines & Technology, Rapid City, SD, June 26-28, 1985.

Udd, J.E. et Billette, N.R. "La Recherche Minière à CANMET: Son impact industriel" Colloque sur la Recherche Minérale, son impact sur la rentabilité, Québec City, Québec, 18 et 19 fevrier 1986, page 417.

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Bigu, J. "Theoretical models for determining radon and thoron daughter levels in Canadian underground uranium mines - A comparison with experimental data"; Health Physics 48:4:371-399, April 1985.

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Bigu, J. "Radon daughter and thoron daughter deposition velocity and unattached fraction under laboratory-controlled conditions and in underground uranium mines"; J Aerosol Sci; 16:2:157-165; 1985.

Bigu, J. and Kaldenback, R. "A microprocessor based continuous monitor with alpha-spectroscopy capabilities for the determination of radon, thoron and their progeny"; Radiation Protection Dosimetry 12:3:251-260; 1985.

Contestabile, E. and Craig, T.R. "Use of shaped charges in mining operations"; CIM Bulletin Vol. 78: number 884, pp 41-46, Dec. 1985.

Davé, N.K., Lim, T.P. and Cloutier, N.R. "Ra-226 concentrations in blueberries (Vaccinium Angustifolium Ait.) near an inactive uranium tailings site in Elliot Lake, Ontario, Canada"; Environmental Pollution Series B 10:301-314, 1985.

Feng, K.K. "Spontaneous combustion of Canadian coals"; CIM Bulletin 78:877: 71-75; 1985.

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Lawson, A., Vergeer, H.C., Drummond, W., Mogan, J.P. and Dainty, E.D. "Performance of a ceramic diesel particulate trap over typical mining duty cycles using fuel additives"; SAE Special Volume P-158 - Diesel Particulate Control 117-130.

Mogan, J.P., Vergeer, H.C., Westaway, K.C., Weglo, J.K., Lawson, A., Dainty, E.D. and Thomas, L.R. "Investigation of the CTO emission control system applied to heavy-duty diesel engines used in underground mining equipment"; SAE Special Volume P-158 - Diesel Particulate Control 131-142.

Swan, G. and Zongqi, S. "Prediction of shear behaviour of joints using profiles"; Rock Mechanics & Rock Engineering 18:183-212; 1985.

Swan, G. "A new approach to cemented backfill design"; CIM Bull. 788:884:53; December 1985.

Vergeer, H.C., Gulati, S.T., Mogan, J.P. and Dainty, E.D. "Electrical regeneration of ceramic wall-flow filters for underground mining applications"; SAE Special Volume P-158 - Diesel Particulate Control 143-152.

APPENDIX B

CONTRACTS AND RESEARCH AGREEMENTS

Contract Title	Contractor	Scientific Authority	Status
Theoretical model for predicting low velocity impact sensitivity bubble sensitized slurry explosion	Mining Resource Engineering	K.K. Feng	In progress
Experimental verification of high velocity impact model for slurry explosives projectile impact	Mining Resource Engineering	K.K. Feng	In progress
Evaluation of propagation sensitivity of commercial explosives in 15 cm diameter hole	Mining Resource Engineering	R. Vandebeek	In progress
To co-fund contract with Laval University - La relation entre la prime au renment et productivitie	ERM - MPS	N. Billette	Complete
To carry out field & laboratory testing, field measurements and numerical modelling of excavations in potash	Cominco	G. Herget	In progress
Estimated preproduction and operating costs of mining small mineral deposits by underground methods (UP-R-237)	J.S. Redpath	R. Clarke	In progress
Development of construction and testing of a prototype electro-hydraulic mini scaler (UP-T-155)	Teledyne Canada	J. Pathak	Complete
Identification of underground equipment development potential and its influence on mine design	Brampton Mining	J. Pathak	Terminated (company went bankrupt)
Development, construction and testing of prototype accessories for automation of a down-the-hole drill (UP-V-42)	Vadeko Intnl	J. Pathak	In progress
Determination of the viability of cavitating hydro impact (UP-T-223)	Teledyne Canada	J. Pathak	In progress
Computer blast design program evaluation for large diameter blasthole stopes underground	Mining Resource Engineering	J. Pathak	In progress
Canadian mining industry capital and operating indices	Dynatec	R. Clarke	Complete

Contract Title	Contractor	Scientific Authority	Status
Development of underground mining methods for exploitation of high grade uranium deposit	DSMA Atcon Ltd.	R. Clarke	In progress
Self instruction teaching package for the design and application of perimeter blasing in open pit mines	Queens Univ.	J. Pathak	In progress
Study of flow conditions arising in horizontal coarse slurry short distance pipelining	C.A. Shook Consultants	L. Geller	In progress
A field test program to evaluate the use of salt backfill in Saskatchewan potash mines	Central Canada	G. Herget	In progress
New Brunswick MDA - Use of backfill in N.B. potash mines	Denison Potacan Potash Company	G. Herget	In progress
Identification of input parameters for numerical modelling of potash strata at IMC	Intnl Minerals & Chemicals Co.	G. Herget	In progress
To study the stability and support in deep mines	Falconbridge Ltd.	D.G.F. Hedley	Complete
Sampling, field testing and material modelling of a surface crown pillar, Les Mines Selbaie, Québec (UP-N-204)	Noranda	M. Bétournay	In progress
Hydrogeochemical investigation of reactive sulphide tailings at the Waite Amulet tailings site	Noranda	N. Davé	In progress
Task 1, Ontario MDA - Part I: In situ determination of dewatered tailings fill properties in Ontario mines	Dome Mines Ltd.	C. Graham	In progress
Task 1, Ontario MDA - Part II: In situ determination of dewatered tailings fill properties in Ontario mines	INCO Limited	C. Graham	In progress
Task V, Ontario MDA - Computer programs specifications for Ontario mining industry		R.F. Boyle	Under Negotiations

Contract Title	Contractor	Scientific Authority	Status
Task III, Ontario MDA - Use of consolidated fills for controlling violent pillar failure in Ontario mines		D.G.F. Hedley	Under Negotiations
Task V, Ontario MDA - In situ properties of backfill alternatives in Ontario mines		D.G.F. Hedley	Under Negotiations
Ontario MDA - Simulation of bulk mining at depth with backfill in Ontario mines		Y.S. Yu	Under Negotiations
Task VII, Ontario MDA - Part III: Liquifaction of potential of dense backfill		C. Graham	Under Negotiations
Time dependant behaviour of frozen backfill pelletized tailings in underground mines (UP-N-172)	Nantar	M. Gyenge	Complete
Surface crown pillar study: Phase II - Case studies	Roche Associates	M. Bétournay	In progress
Georoc: Technology transfer seminars for the potash industry	RE/SPEC Limited	Y.S. Yu	In progress
Task II, Manitoba MDA: Ground stability evaluation with particular reference to an echelon lensed orebody	Sherritt Gordon Mines	S. Vongspaisal	In progress
Task III, Manitoba MDA: Communication system for isolated areas in mines	Sherritt Gordon Mines	S. Vongspaisal	In progress
Task IV, Manitoba MDA: Geomechanical database for ground control in deep mines	INCO Limited	Y.S. Yu	In progress
Task I, Manitoba MDA: Develop vertical block method design guidelines for a steeply dipping orebody technique	INCO Limited	Y.S. Yu	In progress
Development of an underground communication system for Canadian mining applications		R.O. Tervo	Contract cancelled

Contract Title	Contractor	Scientific Authority	Status
Task V, Manitoba MDA: Optimization of blast design for blasthole mining operators		J. Pathak	Under negotiations
Task VI, Manitoba MDA: Delayed backfill consolidation		C. Graham	Under negotiations
Field calibration of 3 new fibre measuring techniques with each other and with other existing methods	Metrex	G. Knight	Contract cancelled
Field calibration of 3 new fibre measuring techniques with each other and with other existing methods	Ontario Research Foundation	G. Knight	Contract cancelled
Production of portable microprocessor controlled in multisize range aerosol counting system for use in underground mine environments	Mono Research Labs	S.G. Hardcastle	In progress
The development of a new semiconductor alpha portable detection system (UP-T-234)	Thompson and Neilson	J. Bigu	In progress
Radon Gas Fluxmeter	Pylon Electronic Development	J. Bigu	In progress
Methanol fuel as a transportation fuel in mining operations (UP-I-103)	INCO Limited	P. Mogan	Complete
Determination of the PAH partition ratio and nature of mutagens generated by catalytic purifiers	Laurentian Univ.	P. Mogan	In progress
Completion of pretial phase of diesel emissions reduction - Part II	Ontario Research Foundation	E.D. Dainty	Complete
A study to determine friction factors of mine airways	Queens Univ.	M. Gangal	Complete
Examination of impact of polynuclear aromatic hydrocarbon explosion in underground mines	McMaster Univ.	P. Mogan	In progress

Contract Title	Contractor	Scientific Authority	Status
Examination of the 100% methanol or pilot diesel methanol engine as a power source for underground mines	INCO Limited	P. Mogan	In progress
Development of wire mesh particulate oxidizer traps using full additives (UP-E-183)	Engine Control Systems	E.D. Dainty	In progress
Modifications and provisions of Jarco 500 LHD diesel machine for environmental impact trials of emissions reduction devices - Phase I	CIL Incorporated (Jarvis)	E.D. Dainty	Complete
Provision of a Jarco 500 LHD diesel machine for underground environmental impact trials of emissions reduction devices - Phase II	CIL Incorporated (Jarvis)	E.D. Dainty	In progress
Completion of systems development and adaptation phase of CANMET diesel emissions reduction program - Part III	Ontario Research Foundation	E.D. Dainty	In progress
Determination of turbulence effects on the severity of dust-air explosions	McGill Univ.	K.J. Mintz	In progress
Reclamation study of pyritic tailings using float and gypsum at Sullivan concentrator, Kimberley, B.C.	Cominco	N. Davé	Complete
Ecological engineering	INCO Limited	N. Davé	In progress
Hydrogeochemical investigation of reactive tailings at the Waite Amulet tailings site	Noranda Research Centre	N. Davé	In progress
A comparative study of 3 methods of reducing acid generation and metals release from waste rock	Falconbridge Limited	N. Davé	In progress

APPENDIX C

REPRESENTATION ON TECHNICAL COMMITTEES

INTERNATIONAL

CANADIAN SUBCOMMITTEE OF THE INTERNATIONAL ELECTROTECHNICAL COMMISSION, TECHNICAL COMMITTEE 31

Electrical Apparatus for Explosive Atmospheres (chairman)	J.A. Bossert
Subcommittee 31G (member)	G. Lobay
Subcommittee 31H (member)	K.J. Mintz

INTERNATIONAL ELECTROTECHNICAL COMMISSION
SUBCOMMITTEE 31A

Flameproof Enclosures (chairman)	J.A. Bossert

INTERNATIONAL SOCIETY FOR ROCK MECHANICS (ISRM)

Commission on Case Histories	D.G.F. Hedley
Commission on Fracture Toughness Testing of Rock	G. Swan
Committee on 1987 ISRM Congress, Montreal (General Chairman)	G. Herget

INTERNATIONAL STANDARDS ORGANIZATION
CANADIAN ADVISORY COMMITTEE

Committee on Certification - CAOCO (member)	J.A. Bossert
Technical Committee 41/Subcommittee 3, Conveyor Belting (member)	K.J. Mintz
Technical Committee 146 - Air Quality and Working Groups, SiO_2 and Inorganic Fibres (member)	G. Knight

INTERNATIONAL TUNNELLING ASSOCIATION

Tunnelling Association of Canada (member)	J.E. Udd

ORGANIZATION FOR ECONOMIC CO-OPERATION AND DEVELOPMENT (OECD)

International Group of Experts on Unstable Substances (IGUS) (national representative)	R.R. Vandebeek
IGUS - Ammonium Nitrate Working Group (co-leader)	R.R. Vandebeek
NEA International Intercalibration and Intercomparison Program for Radon, Thoron and their Daughters (member)	J. Bigu

UNITED NATIONS

Group of Experts on Explosives (delegate)	R.R. Vandebeek

UNITED STATES OF AMERICA

INSTRUMENT SOCIETY OF AMERICA

Committee SP 12 Instruments for Use in Hazardous Locations (member)	J.A. Bossert

COLLABORATIVE PLANNING COMMITTEE FOR DIESEL EMISSION REDUCTION R & D

(CANMET representative)	E.D. Dainty

CANADA - FEDERAL

CANADIAN GOVERNMENT SPECIFICATIONS BOARD (CGSB)

Diesel Fuel Panel of the CGSB Subcommittee on Middle Distillates (member)	J.P. Mogan

ENERGY, MINES AND RESOURCES CANADA (EMR)

Committee on Radioactive Waste Containment (member)	G.E. Larocque
Occupational and Environmental Research for Uranium Production, Joint Panel (secretary)	R. Tervo
(member)	J. Bigu
Uranium Resource Appraisal Group: Subcommittee on Reasonably Assured Resources of Uranium (Chairman)	A. Fustos
Uranium Resource Appraisal Group: Subcommittee on Estimated AdditionalResources of Uranium (member)	A. Fustos
Uranium Resource Appraisal Group: Subcommittee on Economics of Supply and Demand for Uranium (member)	A. Fustos
Uranium Resource Appraisal Group (member)	A. Fustos

TRANSPORT CANADA

Technical Committee on Dangerous Goods (member)	R.R. Vandebeek

CANADA - OTHER

CANADIAN GAS ASSOCIATION

Gas Fired Appliances for Hazardous Locations, No. CGA 2.25 (member)	G. Lobay

CANADIAN GEOTECHNICAL SOCIETY

Ottawa Geotechnical Group (executive member)	M. Bétournay
Subcommittee on Tunnelling (member)	M. Gyenge

CANADIAN INSTITUTE OF MINING AND METALLURGY (CIM)

Ad-Hoc Committee on Mining and Mineral Processing Research (member)	J.E. Udd
(member)	N. Billette
Algoma Branch (Laboratory representative)	B. Arjang
Ottawa Branch (executive committee member)	D. Walsh
Committee on Education for the Mineral Industry (Chairman)	J.E. Udd
(member)	N. Billette
Rock Mechanics and Strata Control Committee (vice chairman)	J.E. Udd
Subcommittee on Backfill (member)	G. Swan
Subcommittee on Rockbursts (vice chairman)	C.B. Graham

CANADIAN ROCK MECHANICS ASSOCIATION - RMSCC

Subcommittee on Non-Explosive Breakage Methods (member)	M. Gyenge
Subcommittee on Monitoring (member)	G. Herget
Subcommittee on Soft Rock (member)	G. Herget

CANADIAN STANDARDS ASSOCIATION

Standards Steering Committee on Electrical and Mechanical Mines Safety (vice-chairman)	J.A. Bossert
Technical Committee for "Flameproof Diesel-Powered Vehicles for Use in Gassy Underground Mines" M424 (Chairman)	E.D. Dainty
Technical Committee on Accoustics and Noise Control (Construction & Mining Machines - Task Force on Occupational Noise) (member)	M. Savich
Technical Committee on Fire Resistant Conveyor Belting, No. M4.22 (member)	K.J. Mintz
Technical Committee on Fire Resistant Hydraulic Fluids, No. M4.23 (member)	K.J. Mintz

CANADIAN STANDARDS ASSOCIATION
CANADIAN ELECTRICAL CODE, PART I

Steering Committee (member)	J.A. Bossert
Subcommittee on Section 18 (Chairman)	J.A. Bossert

CANADIAN ELECTRICAL CODE, PART II

Subcommittee on CSA Standard C22.2, No. 30:
Explosion Proof Enclosures for Use in Class I, Groups,
A, B, C and D
Hazardous Locations (member) ..... J.A. Bossert

Subcommittee on CSA Standard C22.2, No. 137:
Luminars for Hazardous Locations (member) ..... G. Lobay

Subcommittee on CSA Standard C22.2, No. 152:
Combustible Gas Detection Equipment (member) ..... G. Lobay

Subcommittee on CSA Standard C22.2, No. 157:
Intrinsically Safe and Non-Incendive Equipment for
Use in Hazardous Locations (vice-chairman) ..... G. Lobay

Subcommittee on CSA Standard C22.2, No. 159:
Plugs and Receptacles for Hazardous Locations (member) ..... G. Lobay

Subcommittee on CSA Standard C22.2, No. 174:
Cables to Used in Hazardous Locations (member) ..... G. Lobay

CANADIAN ELECTRICAL CODE, PART V

Committee on CSA Standard C22.5
Use of Electricity in Mines (member) ..... G. Lobay

CANADIAN URANIUM PRODUCERS METALLURGICAL COMMITTEE
(members) ..... N.K. Davé
T.P. Lim

SAULT COLLEGE, ELLIOT LAKE

Advisory Committee for the Ventilation Technician Option
of the Mechanical Technology Course (members) ..... S. Hardcastle
R. Tervo

CAMBRIAN COLLEGE, SUDBURY

Advisory Council for Mining Ciriculum (member) ..... C.B. Graham

INOTITAT DE RECHERCHE EN SANTE ET SECURITE DU TRAVAIL

Comité des sciences naturelles et génie ..... N. Billette

APPENDIX D

CONTACTS, MEETINGS, FIELD TRIPS, AND JOINT CONSULTATIONS

CONTACTS, MEETINGS AND FIELD TRIPS

As a research organization performing applied work which is largely related to the needs of industry, it is essential that there should be excellent communications linkages. To that end, contacts at all levels with mining companies, manufacturing firms, consultants, universities and colleges, and federal and provincial government departments, are very frequent. Because the mandate of the Division is to serve the hard rock and non-coal soft rock mining industry, the staff travel often. The statistics which are mentioned and the lists of organizations contacted give some measure of the breadth of the contacts. In some ways it does not do justice to state simply that contacts are "frequent". In a great many cases they are more than that - as often as daily or weekly in the instances when research is needed urgently (as in the rockburst project and in some of the Mineral Development Agreement projects).

During the year, on behalf of the Division, the Director made overview presentations of the total research activities on eleven occasions. Two of these presentations were given to technical delegations from the People's Republic of China, while others were given as follows: at joint meetings with the United States Bureau of Mines in Pittsburg, Pennsylvania, and Spokane, Washington; at Canadian locations including Timmins, Ontario; Bathurst, New Brunswick; Thompson and Winnipeg, Manitoba; Quebec City, Quebec; and Bells Corners. The Director also presented a Canadian position on international cooperation in research applied to automated mining and tunneling at a meeting at Cambridge, Massachusetts, in November.

One of the most significant changes that took place in the year was the rapid growth in the projects which are being undertaken jointly with industry. New projects have been initiated in Manitoba, Ontario and New Brunswick. In each of these provinces there have been meetings with representatives of the industry in order both to plan new projects and to report on those in progress. Such meetings are very valuable and welcomed for two important reasons.

First, meetings with industry to establish research priorities and to plan joint projects guarantee that the research will be relevant to real needs. Second, such meetings represent further opportunities to reinforce contacts with industry at several levels. In two meetings concerning the Ontario MDA, at Timmins for example, most of the mine operators in the province were represented. The improved linkages can only have a very positive effect on the orientation of the Division.

JOINT PROVINCIAL/FEDERAL/UNIVERSITIES/INDUSTRY/INTERNATIONAL CONSULTANTS

PROVINCIAL

Centre de Recherches Minérales, Québec
Manitoba Mines Branch
Ontario Hydro
Ontario Ministry of Labour
Ontario Ministry of Natural Resourses
Saskatchewan Ministry of Labour

FEDERAL

Atomic Energy
Canadian Coast Guard
Labour Canada
National Defence

UNIVERSITIES

Laurentian University
Laval University
McGill University
McMaster University
Queen's University
Sherbrooke University
University of Alberta
University of British Columbia
University of Ottawa
University of Quebec
University of Saskatchewan
University of Toronto
Waterloo University

INDUSTRY
(*Denotes Frequent Contacts)

Alpha Nuclear Company, Mississauga, Ont.
Analygas Systems Ltd., Scarborough, Ont.
Beaver Construction Group, Dorval, Que.
Brenda Mines Ltd., Peachland, B.C.
Brunswick Mining and Smelting Corp. Ltd., Bathurst, New Brunswick
CIL Ltd., Montreal, Que.*
CIM, Montreal, Que.*
Campbell Red Lake Mines Ltd., Balmertown, Ont.*
Canadian Arsenals, Montreal, Que. *
Canadian Diamond Drilling Association, Don Mills, Ont.
Canadian Geoscience Corp., Vancouver, B.C.

Canadian Mine Development Ltd., Mississauga, Ont.
Canadian Standards Association, Toronto, Ont. *
Cape Breton Development Corp. (CBDC), Lingan Mine, Sydney, N.S. *
Central Canada Potash, Colonsay, Sask. *
Coal Mining Association Centre, Calgary, Alta.
Cominco Ltd., Kimberly, British Columbia *
Combustion Engineering Ltd., Toronto, Ont.
DSMA Atcom, Toronto, Ont.
Denison Mines Ltd., Elliot Lake, Ont. *
Denso Canada Ltd., Agincourt, Ont.
Detour Lake Mines, Timmins, Ont.
Dickenson Mines Ltd., Balmertown, Ont.
Dome Mines Ltd., South Porcupine, Ont.
Dynatec Ltd., Richmond Hill, Ont.
EDA, Toronto, Ont. *
Engine Controls Systems Ltd., Aurora, Ont.
Expro Chemicals Products Inc., Valleyfield, Que.
Falconbridge Ltd., Falconbridge, Ont. *
Golder Associates, Mississauga, Ont.
H.A. Simons Ltd., Vancouver, B.C.
HDRK Research, Sudbury, Ont. *
Hands Fireworks, Papineauville, Que. *
Hudson Bay Mining and Smelting Co. Ltd., Flin Flon, Man.
Hyundai Canada Ltd., Unionville, Ont.
INCO Metals Ltd., Sudbury, Ont. *
INCO Metals Ltd., Manitoba Division
International Mining and Chemicals Corp. Sask.
J.S. Redpath Ltd., North Bay, Ont.
JKS/Boyles Diamond Drilling Manufacturers, Toronto, Ont.
Jarvis Clark, Burlington, Ont.
Kerr Addison Mines Ltd., Larda Lake, Ont.
Key Lake Mining Corp., Saskatoon, Sask.
Kidd Creek Mines Ltd., Timmins, Ont.
Kiena Gold Mines Ltd., Val D'Or, Que.
LEQ Measurements, Toronto, Ont.
Les Mines Selbaie, Joutel, Que. *
Levitt-Safety, Toronto, Ont.
Lornex Mining Corp. Ltd., Logan Lake, B.C.
MLH Whaling and Associates (Research) Ltd., Sudbury, Ont.
Macassa Mine, Kirkland Lake, Ont.
Mattabi Mines Ltd., Ignau, Ont.
Miltor Ltd., Sudbury, Ont.
Mines Accident Prevention Association, North Bay, Ont.
Mines Sigma (Quebec) Limitee, Val D'Or, Que.
Monenco, Montreal, Que.
Niobec, St. Nonoie, Que. *
Noranda Inc., Pointe Claire, Que. *
Oak Supply Company, Toronto, Ont.
Ontario Centre for Machinery Development, Sudbury, Ont.
Ontario Centre for Microelectronics, Ottawa, Ont.
Ontario Mining Association, Ottawa, Ont.
Ontario Research Foundation, Toronto, Ont. *
Philips Cables Ltd., Brockville, Ont.
Potash Corp., Saskatoon, Sask. *
Quebec Metal Mining Association

Ramsey Engineering, Toronto, Ont. *
RE/SPEC Ltd., Calgary, Alta.
Rio Algom Ltd., Elliot Lake, Ont.
Roche Ltée., Ste-Foy, Que.
Sheritt Gordon Mines, Lyn Lake, Man.
Similkameen Mine, Pencton, B.C.
Soquem, Bagotville, Que.
Teledyne Canada, Thornbury, Ont.
Troy Manufacturing, Toronto, Ont.
Uniroyal Ltd., Bracebridge, Ont.
Vadeko International Ltd.,, Mississauga, Ont.
Vintex Inc., Brampton, Ont.
Western Resources, Campbell River, B.C.
Westar Mining Ltd., Sparwood, B.C. *
Wolf Mountain Coal, Vancouver, B.C.

INTERNATIONAL

Argone National Laboratory, U.S.A.
Armtec Controls, New Hampshire, U.S.A.
Australian Atomic Energy Commission
Batelle Laboratories, Columbus, Ohio, U.S.A.
Bharat Gold Mines, Gov't of India
Brazilian Potash Mining Company
Century Oils Ltd., London, U.K.
Chercher Explosives Research, France
Chamber of Mines, South Africa
Coal Mining Research Institute, Essen, West Germany
Conzinc Mine, Broken Hill, Australia
Corning Glass Works, New York, U.S,A.
Electric Power Research Inst. Palo Alto, California, U.S.A.
E.Z. Co. Ltd., Australia
Eickhoff Corp., Pittsburgh, U.S.A.
General Monitors Corp., Costa Mesa, California
IEC Central Office, Geneva
J.H. Fenner & Co. Ltd., Marfleet, Hull, U.K.
Korean Trade Missions
Michigan Technical University, Lasing, MI, U.S.A.
Mines de Potasse D'Alsace
MSHA, Triadelphia, W. Virginia, U.S.A.
Oklahoma University, Oklahoma, U.S.A.
Penn State University, Pack, PA, U.S.A.
Peoples Republic of China
Petro Mesa
Rand Mines, South Africa
Reliance Electric Ltd., Cleveland, Ohio, U.S.A.
Scandura, U.S.A.
Selco, London, U.K.
Tara Mines Ltd, Knockumber, Ireland
Tokyo Gas Co., Tokyo
U.S. Bureau of Mines, Pittsburgh, U.S.A.
U.S. Mine Safety Health Administration
Wajax Ltd., U.K.
Westfalia, Lunen, West Germany

APPENDIX E

COST RECOVERY

COST RECOVERY

Company	Number of samples/tests	Amount invoiced
Canadian Standards Association (CSA)	54	$11,305.00
Dosco Overseas	3	384.00
J.H. Fenner	10	500.00
Ingersol Rand	1	100.00
Vintex Incorporated	2	100.00
Canadian General Electric	2	300.00
Appleton Electric	21	4,954.00
Barrington International	3	350.00
Phillips Cable	17	3,138.00
Babcock Harwood	4	400.00
NEI Mining	4	654.00
Crouse Hinds	6	1,279.00
Cominco	1	150.00
Brush Electric	2	284.00
GEC High Voltage	2	200.00
Western Concord	1	50.00
Scharf Company	3	300.00
Combustion Research	2	300.00
General Mining & Engineering	4	345.00
NEI Peebles	1	100.00
Dow Corning	2	100.00
Foxboro Canada	1	275.50
MSA Canada	2	200.00
NEI Baldwin	1	184.50
HL Blanchford	14	3,091.00
Thomas Betts Corporation	1	184.50
Tom Roy Fibreglass	1	184.50
General Manitous	4	1,133.00
Safety Supply	2	369.00
Thermo Electric	4	738.00
Commercial & Control Engineering	3	554.50
Union Carbide	8	1,623.00
Uniroyal Limited	26	7,432.00
Cape Breton Development Corporation	2	369.00
Magnatrol International	4	796.00
Georgia Duck	1	489.00
Eickhoff Corporation	3	598.00
Smokey River Coal	1	1,185.00
Alphair	2	436.00
Minelec Limited	5	920.00
Harrison Corporation	1	184.00
Anderson Strathaldge	3	553.00
Sullivan Sales	2	369.00
Goodyear Canada	4	1,332.00
Levitt Safety	2	369.00
Milton Drilling	2	7,772.00
Canadian Geological Association	1	550.00

Cost Recovery (cont'd)

Company	Number of samples/tests	Amount invoiced
Mandel Engineering	2	370.00
Minelec	3	552.00
Foundrometers	1	184.00
Harrison Saturn	1	184.00
Stedfast Electric	2	369.00
Croda Canada	7	1,475.00
Canada Wire & Cable	2	550.00
Gullick Dobson	1	185.00
Shaver Almoc Industries	1	184.00
Transmitton Limited	2	370.00
Sub-total		$65,040.00

Cost Recovery (cont'd) - Elliot Lake Laboratory

Company	Number of samples/tests	Amount invoiced
Dome Mines	75	$ 412.50
Evco Industries	33	181.50
Goot Newfoundland	46	253.00
Griffith Mine	23	126.50
Giant Yellowknife	31	170.50
Hudson's Bay Mine	5	27.50
Indusmin	303	1,666.50
Indian & Northern Affairs	9	49.50
Kidd Creek Mines	375	2,062.50
Les Mines Camchib	8	44.00
Lac Minerals	8	44.00
L'Association des Mines	20	110.00
Noranda Research	46	253.00
Noranda Mines	38	209.00
University of Toronto	15	82.50
Ontario Hydro	7	38.50
Parmour Porkupine	30	165.00
Renobie Mines	6	33.00
Union Carbide	51	280.50
St. Michael's Hospital	8	44.00
Sub-total		$6,270.00
Grand total		$71,310.00

Number of billings - 146

Number of companies - 81

Number of samples/tests - 1,404

Amount invoiced - $71,310.00

APPENDIX F

PROFESSIONAL, TECHNICAL AND ADMINISTRATIVE STAFF AND STAFF CHANGES

PROFESSIONAL, TECHNICAL AND ADMINISTRATIVE STAFF

NAME	DEGREES AND DIPLOMAS	OCCUPATIONAL CATEGORY
J.E. Udd	B.Eng., M.Eng., Ph.D. (McGill); P.Eng.	Director
J.E. Evans		Secretary
ADMININSTRATIVE SERVICES		
M. Hamel		Publications
D.M. Hill		Office Manager
C. Sleeth		Finance
E.C. Tupper		Admin Officer
CANADIAN EXPLOSIVE ATMOSPHERES LABORATORY		
J.A. Bossert	B.Sc. (Queen's), P.Eng.	Manager
M.I. Inglis		Secretary
M.J. Boyle	Dipl. (Mech. Tech.) (Algonquin)	Technologist
E.D. Dainty	B.Sc., M.Sc., (Toronto) P.Eng.	Res. Sci.
E.E. Dainty	Dipl. (Inst. Tech.) (Algonquin)	Technologist
J.A.D. Ebersole	Dipl. (Electr. Tech.) (Ryerson)	Technologist
G. Lobay	B.Sc. (Manitoba), P.Eng.	Engineer
K.J. Mintz	B.Sc., M.Sc. (UBC); PhD. (Toronto)	Res. Sci.
J.P. Mogan	B.A.Sc. (Toronto), P.Eng.	Res. Sci.
M.J. Ralph	Dipl. (Elect. Tech.) (Algonquin)	Technologist
J.A. Vallieries	Dipl. (Mech. Tech.) (St. Micheal's)	Technologist
CANADIAN EXPLOSIVES RESEARCH LABORATORY		
R.R. Vandebeek	B.Sc., M.Sc. (Carleton)	Manager
J. Campbell		Secretary
R. Augsten	Dipl. (Agri. Tech.) (Jena, Germany)	Technologist
K.C. Cheng	B.Sc., M.Eng. (Tainan Chen-Kung, Taiwan)	Engineer
E. Contestabile	B.Sc. (Carleton)	Phys. Sci.
T. Craig	Dipl. (Biochem. Tech.) (Algonquin)	Technologist
D. Dinel	Dipl. (Analy. Chem. Tech) (CEGEP)	Technologist
K.K. Feng	B.Sc., P.Eng., M.Sc., Ph.D. (Iowa)	Res. Sci.
D.E.G. Jones	B.Sc., Ph.D. (Western)	Res. Sci.
P. Lee	B.Sc. (Hong Kong Baptist)	Chemist
E. Nagy	Dipl. (Electr. & Mech. Tech.) (Ryerson)	Technologist
E.T. Pike	Dipl. (Chem. Tech.) (Dawson)	Technologist
C.A. Vary	B.Sc. (Ottawa)	Tech. Officer
ELLIOT LAKE LABORATORY		
R.O. Tervo	B.A.Sc. (Toronto), Ph.D. (Bradford); P.Eng.	Manager
H.C. St. Jean		Secretary

ADMINISTRATIVE SERVICES

E. McElrea		Office Manager
J. Nipius		Financial Clerk
A.M. Webster		Reports & Publ'ns Clerk
B. Arjang	B.Sc., M.Sc., Ph.D. (Germany)	Res. Sci.
J. Bigu	M.Sc. (Barcelona), DTC(BA++) (Slurry) Ph.D. (Queen's)	Res. Sci.
Y.M. Boucher	Dipl. (Bio Science Tech.) (St. Clair)	Technologist
K.C. Butler	B.Sc. (Laurentian)	Technologist
N.K. Davé	B.Sc., M.Sc. (Rajastman, India), Ph.D. (Queen's)	Res. Sci.
E. Edwardson		Technologist
A.J. Frattini	Dipl. (Inst. Eng. Tech.) (Ind.)	Technologist
M. Grenier	B.Sc., M.Sc. (Laurentian)	Res. Sci.
D. Hanson	B.Sc., Geol. Eng. (Saskatchewan), M.Sc. Geo. Tech (Minnesota)	Phys. Sci.
S.G. Hardcastle	B.Sc., Ph.D. (Nottingham, England)	Res. Sci.
D.G.F. Hedley	B.Sc., Ph.D. (Newcastle), P.Eng.	Res. Sci.
T. Jewiss	Dipl. (Min. Tech.) (Cambrian)	Technologist
G. Knight	B.Sc. (Birbeck, London)	Res. Sci.
T.P. Lim	B.Sc. (Ottawa), Dipl. (Radio Chem. Tech) (Munich, West Germany)	Phys. Sci.
T. Makuch	B.Sc. (Waterloo)	Phys. Sci.
H.L. Poliquin		Technologist
P. Rochon	M.Sc., (Montreal)	Phys. Sci.
W. Ropchan	Technology (Cambrian)	Technologist
M. Savich	Dipl. (Min. Eng.) (Ljobljan, Yugoslavia), B.Eng., M.Eng. (McGill)	Res. Sci.
J.A. Smith		Technologist
G. Swan	B.Sc., Ph.D. (London); DIC; ARSM	Res. Sci.
L. Tirrul		Technologist
W. Zawadski		Technologist

ROCK MECHANICS LABORATORY

G.E. Larocque	B.Sc. (Carleton)	Manager
J.E. Byford		Secretary
A.B. Annor	B.A.Sc. (Ottawa); M.Eng. (Carleton); P.Eng.	Phys. Sci.
M. Bétournay	B.Sc., M.Sc.A., B.Eng. (McGill); P.Eng.	Phys. Sci.
N. Billette	B.A. (Bourget), B.Sc., M.Sc., Ph.D. (École Polytechnique)	Res. Sci.
A. Boyer	B.Sc. (Montreal)	Phys. Sci.
R. Boyle	B.Sc. (Ottawa)	Phys. Sci.
R.W.D. Clarke	B.Eng. (NSTC), P.Eng.	Engineer
D. Dugmore	Dipl. (Mach.) (CNR); Mech. Draft. (Ontario)	Draftsperson
J. Folta		Draftsperson
A. Fustos	B.S.F./F.E., B.Sc. (UBC); M.Sc. (Carleton); P.Eng.	Engineer
M. Gangal	B.Sc. (Agra, India); M.Sc. (Rohee, India & McGill); Ph.D. (Calgary)	Res. Sci.

L. Geller	Dipl. (Mech. Eng.) (Budapest), B.Sc. (Eng.) (London), M.A.Sc. (Toronto)	Phys. Sci.
B. Gorski	Dipl. (Eng.) (St. Marks)	Technologist
C.B. Graham	B.Sc., M.Sc., (Eng.), (Queen's)	Phys. Sci.
M. Gyenge	Dipl. (Eng.) (Budapest), P.Eng.	Res. Sci.
G. Herget	B.Sc (Goettingen, West Germany); M.Sc., Ph.D. (Munich, West Germany); P.Eng.	Res. Sci.
F. Kapeller	Dipl. (Ind. Elect.) (Austria)	Technologist
R. Jackson	B.A.Sc. (Waterloo); P.Eng.; AECL Employee	Phys. Sci.
P. Lacourse	B.A. Sc. (Laval)	Engineer
J. Pathak	B.Eng., M.Eng. (Sager, India), Ph.D. (Freiberg, Germany)	Engineer
N.A. Toews	B.Sc. (Queen's)	Res. Sci.
S. Vongpaisal	B.Eng., M.Eng., Ph.D. (McGill); P.Eng.	Res. Sci.
D.F. Walsh	B.Sc. (Memorial)	Phys. Sci.
R.J.R. Welwood	B.Sc. (Queen's)	Phys. Sci.
A.S. Wong	B.Sc. (National Taiwan University), M.Sc. (Ottawa)	Phys. Sci.
Y.S. Yu	B.Sc., M.Eng. (McGill)	Res. Sci.

STAFF CHANGES

APPOINTMENTS AND PROMOTIONS

R. Boyle	- Phys. Sci. - RML - 7 August 85
E. Edwardson	- Technologist - ELL - 19 August 85
C.B. Graham	- Phys. Sci. - RML - 8 July 85
D. Hanson	- Phys. Sci. - ELL - 27 January 86
D.M. Hill	- Office Manager - MRL/Administration - 3 March 86 *on secondment from RPO
P. Lacourse	- Engineer - RML - 25 November 85
T. Makuch	- Phys. Sci. - ELL - 2 October 85
P. Rochon	- Phys. Sci. - ELL - 3 June 85
D. Ropchan	- Technologist - ELL - 3 September 85

SEPARATIONS

Transfers

M.K. Gangal	- Research Scientist, Transferred to RML - 1 April 85
C.A. Sabourin	- Office Manager, *on secondment to RPO - 3 March 86

Permanent

G. Swan	- Research Scientist, ELL - 29 November 85
L. Tirrul	- Technologist, ELL - 30 June 86, Retired

Terms

N. Cloutier	- Technician, ELL - 25 October 85
J.A. Evans	- Secretary to Director, MRL - 11 April 86
B. McGurk	- Draftsman, ELL - 31 December 85